Groin and Hip Complexities: Is Prevention viable?

By

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A thesis submitted to the University of Kent in fulfilment of the requirements for the degree of Professional Doctorate in Sport, Exercise and Health Science.

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Foreword

The initiation of this thesis is based on my 13 years work with Premier League Football as a Medical Advisor to Insurers for all the Football Clubs (and other elite sports). Groin and hip pain was a consistent factor and a point of ongoing discussion with the Club's medical personnel who requested that I publish a Groin and Hip Handbook (2012), following on from my 2 Handbooks with the latest evidence on Knees. The Groin / Hip Handbook consisted of 239 latest studies, as well as "bullet points" from 12 International Specialists. Subsequently, I gave many presentations based on my newfound knowledge which ultimately led to the request that I undertake this Professional PhD.

Not only has this time with the thesis been a fascinating journey whereby I have learnt from the multitude of ongoing studies, but also going to all the National and International Conferences on groin and hips and learning from the renowned Specialists. Further, my background of being the physiotherapist for many Provincial and South African Sports teams has given me a very practical approach to the complexity of the groin and hip problem. Thus I believe that combining these elements i.e. evidence-based medicine, knowledge from Conferences and my practical experience, has contributed to a significant and exceptional journey with this thesis.

I am passionate about sharing my newfound knowledge with all my colleagues, including Orthopaedic Surgeons, Post-graduate Sports Doctors and Physiotherapists, Biokineticians and all medical personnel managing sports patients, both nationally and internationally. Also to Coaches working with recreational and elite sports. Thus it is not only the Professional Doctorate itself, but also the contribution I can make to my profession and to the field of sports medicine.

My professional journey in the sporting arena has been very fulfilling and the increasing learning and ongoing knowledge of each sport and each position therein, has been challenging and most rewarding. This Professional PhD is the climax of my profession.

My sincere thanks to Professor Passfield whose positive approach and direction with this thesis has been invaluable. Also thanks to Janine Gray (PhD) for her insightful contribution and my family and friends who have always supported me along the way.

I will continue with my love of learning and ongoing knowledge and hopefully contribute to the constant changes and upgrades in our medical profession.

Declaration

Note, no part of this thesis has been submitted in support of an application for any degree or other qualification of the University of Kent, or any other University or Institution of learning.

Relevant Accomplishments

- I have been the physiotherapist for many South African Sports including Rugby (1992), Hockey 1993-1998), Cricket (1994), Surf Lifesaving (1992 -1996), 2 Commonwealth Games (1994,1998), 2 All Africa Games (1995, 1999), Maccabi Games (2005).
- Currently on the SA Board for Adaptive Surfing as the Physiotherapist and Classification officer.
- I have recently been privileged to win 2 South African awards:

  South African Sports Medicine Association (SASMA) (2019): Merit Award for my "invaluable contribution to Sports Medicine in SA".

  Sports Physiotherapy South Africa (2018): Honorary Award for my "achievement and dedication to Sports Physiotherapy over the years".

Presentations / Workshops

My greatest passion is to share my ongoing knowledge with all sectors of people and thus have been giving Presentations / Workshops to all my colleagues including Orthopaedic Surgeons, Physicians, Hip Surgeons, Sports Physicians, SEMS Masters doctors, Masters Physio students, Physios, Biokineticists, Nursing and Occupational Therapists. Also to coaches of all different sports in the Townships / Informal settlements.

The most presented topic and a strong passion of mine is that of "Medico-Legal Ethical issues in Elite sports", which I have been giving for the past 20 years (with growing perception of the under-rated complexities involved). Since undergoing this thesis, Hips and Groin have been equally important to share with many people.

The presentations have varied, from coaches in informal settlements in Cape Town - Langa (2017, 2018, 2019); Khayalitsha (2017, 2018, 2019) to Premier League Football Clubs - Chelsea Football Club (2008); Reading Football Club (2008); Manchester City Fooball Club (2014); Arsenal Football Club - SEMS MSc Doctors and Physios (2015, 2016); Nottingham Forest Football Club (2015); Blackburn Rovers Football Club (2017); Crystal Palace Football Club (2019) and Bournemouth Football Club (2019).

I have presented many different topics around the world which include World Cup Rugby Medical Congress – South Africa (1995); World Cup Cricket Medical Seminar, South Africa (2003); British Sports Conference, London (2007); Ireland Sports Physio (2008, 2012, 2015); BIMMS Doctors and Osteopaths, England (2012); Gilmores Clinic, London (2013); Perform, Spire Hospital – Midlands, England (2015, 2016); Saracens Rugby Club, England (2012, 2014); Montpellier Rugby Club, France (2005); SW Districts Rugby, England (2008); Wales Rugby Clubs (2014); Ghana Football Association, Accra, Ghana (2014); NE Symposium Sports Injuries and Exercise Medicine, England (2016) and the Isokinetic Conference, England and Italy (2013, 2014, 2015, 2016, 2017, 2018).
Further, in 2017 I was invited to be part of a workshop on Innovative/Biological Therapies in Elite Sport, London.

I particularly enjoy sharing with young clinicians e.g. Leeds University - Physiotherapists (2008); Huddersfield University - Physiotherapists (2009 /2010); London Metropolitan University - Sports Therapists (2009, 2010); Middlesex University (2007, 2008, 2009, 2010; 2011 x 2, 2012, 2014); Kent University (2011 x 2; 2012; 2013); London Metropolitan University (2011); University of East London (2015, 2016); 4 Universities in North India (2012, 2017); Irish Sports Physio association (2015); Orthopaedic Manipulative Physiotherapy Group SA (2018); Stellenbosch University to SEMS Doctors (2018, 2019).

I have given further presentations to specific groups e.g. Sky Pro cyclists – London (2011); Cricket coaches SA (including National and Academy cricket coaches) (1999-2006); South

African Sports Physiotherapy Congress - Keynote Speaker (2015); Adaptive Surfing South Africa Seminar (2016); SA Sports Medicine Congress (2012, 2013, 2017, 2019); South African Society for Hip Arthroscopy (SASHA) Conference. (2017); SA International Tendinopathy Conference (2010); Sports Interest Group (SA) (2017, 2018, 2019); Sports Physiotherapy (2017); Medicine Africa Cycling Congress (2017); Sports Physicians (SEMS) - Sports Science Institute of SA (SSISA) (2017, 2018); Biokineticians at SSISA (2018, 2019) and Cape Rugby Medical Congress (2018)

I have also presented to Corporates and Business College e.g. GIBS Business College; Eskom; Corporate Connnections; Fidential; Luasa and Rotary – South Africa and Nuffield Health, London, England (2015).

There have been many requests for presentations on anatomical structures (including specifically hips and groin), as well as medical conditions, by Insurers and lawyers in London e.g. Clyde and Co. (2011); Lloyds of London (2015, 2017), QBE (2009, 2010, 2014, 2016, 2017), Bluefin (2016), Brit Insurance (2012, 2014, 2016), XL Catlin (2016) and HCC (2012, 2016, 2018).

The presentations and workshops on groin and hips have made this thesis very meaningful for me. Due to my work in all the different sports at different levels i.e. from grassroots to elite sport, I am well aware that there has been a dearth of knowledge regarding groin and hip management. To investigate all the knowledge and complexities of groin and hips and thus be able to share with relevant people, has been most rewarding. My focus has been on prevention of these groin and hip problems in the first place. With a plethora of research (which is constantly evolving) and ongoing discussions with the experts in this field, I believe that I have imparted knowledge to the people working in a number of the sports areas and many have told me how they are now implementing structures to prevent the injuries where possible.

<u>Motivational talks</u> including:

- "The life of the Sportsman / Woman"
- "On top of your Game: Sports / Business"- "Role of Woman in a Man's Business / Sport World"
- Excellence in Sports / Life **-**
- Reflect and Connect- MTI Conference, London Keynote speaker. (2014).

Published a number of Studies and Handbooks.

<u>Studies</u>

Millson, H. B., Gray, J., Stretch, R. A., & Lambert, M. I. (2004). Dissociation between back pain and bone stress reaction as measured by CT scan in young cricket fast bowlers. British journal of sports medicine, 38(5), 586–591.

Millson, H., Hechter, G., Aginsky, K., Bolger, C., and Saunders C. (2005). The nature and incidence of injuries in a Currie Cup rugby team from 2001 to 2003. South African Journal of Sports Medicine, 17(2), 13 – 17.

Viljoen, W., Saunders, C., Hechter, G., Aginsky, K., Millson,H. (2009). Training volume and injury incidence in a professional rugby union team. South African Journal of Sports Medicine, 21(3).

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Millson H. (2012). "An introduction to physiotherapy issues in groin pain" BJSM Blog. Karim Khan

Millson H. (2013) "Groin and Hip Quandaries". Sportex Medicine.

Millson H. (2012) Quandaries in Groin and Hips". "British Institute of Musculo-Skeletal Medicine (BIMMS), Abstract. "Our Sporting Life".

Handbooks:

- Millson, H, (2006) Knees: The latest International Evidence - Anterior Cruciate Ligament, Meniscal Transplant, Chondral Lesion Repair.

- Millson, H. (2008) Knees: The latest International Evidence - Medical Legal Ethics, Chondral Lesion Repair, Anterior Cruciate Ligament, Meniscal Transplant.

- Millson, H. Handbook (2012) Groin and Hips. The latest International Evidence.

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Contents Page: List of Abbreviations

ACL:	Anterior Cruciate Ligament
Abd:	Abductor
Add:	Adductor
Add Mag:	Adductor Magnus
ADL:	Activities of Daily Living
AL:	Adductor Longus
ANT:	Anterior Reach Test
AP:	Athletic Pubalgia
ARGP:	Adductor-Related Groin Pain
BESS Test:	Balance Error Scoring System
BMI:	Body Mass Index
BMO:	Bone Marrow Oedema
CC:	Closed Chain exercises
CT:	Computerized Tomography
CTA:	Computed Tomography Arthrography
DLS:	Double-legged Squatting
EHAD:	Eccentric Hip Adduction strength
EHAB:	Eccentric Hip Abduction strength
EMG:	Electromyographic
Exc Th:	Exercise Therapy
Ext:	External
FAI:	Femoro-Acetabular Impingement
FAIS:	Femoro-Acetabular Impingement Syndrome
FMA:	Football Medical Association
FMS:	Functional Movement Screening
Glut Med:	Gluteus Medius
Glut Max:	Gluteus Maximus
GPS:	Groin Pain Syndrome

Abbreviations continued

Glut:	Gluteus
GT:	Gluteal Tendinopathy
HABD:	Hip Abduction
HAGOS:	The Copenhagen Hip and Groin Outcome Score.
HHD:	HandHeld Dynamometer
Hip Abd:	Hip Abductor
Int:	Internal
IO:	Internal Oblique
IP:	Ilio Psoas
IPP:	Injury Prevention Programme
IRR:	Injury Rate Ratio
LBP:	Low Back Pain
LMR:	Lichtenstein Mesh Repair
LSGP:	Long Standing Groin Pain
LT:	Ligamentum Teres
MBR:	Modified Bassini's Repair
MR:	Magnetic Resonance
MRA:	Magnetic Resonance Arthrography
MRI:	Magnetic Resonance Imaging
MT:	Musculo-Tendinous
NM:	Neuromuscular
NWB:	Non Weight-Bearing
OA:	Osteo Arthritis
OP:	Osteitis Pubis
OS:	Osteitis Symphysis
PAP:	Post-Activation Potentiation-based exercises
PFP:	Patella Femoral Pain
PFPS:	Patella Femoral Pain Syndrome
PL:	Posterolateral; PM: Posteromedial
Post-op:	Post-operative
PPT:	Physical Performance Tests

Abbreviations continued

PS:	Pubic Symphysis
QASLS:	Qualitative Assessment Tool
QL:	Quadratus Lumborum
RA:	Rectus Abdominus
RF:	Rectus Femoris
ROM:	Range of Motion
RTP:	Return to Play
RTS:	Return to Sport
RWU:	Re-Warm-Up
SEBT:	Star Excursion Balance Test
SHA:	Side-lying Hip Abduction
SHA-MR:	SHA with hip medial rotation
SIJ:	Sacro- Iliac Joint
SLS:	Single Leg Squat
SRGP:	Sports Related Groin Pain
TAPP:	Transabdominal Preperitoneal repair
TEP:	Totally Extraperitoneal repair
TFL:	Tensor Fascia Latae
TrA:	Transversus Abdominis
TREPP:	TransREctus sheath PrePeritoneal
US:	Ultrasound
WB:	Weight-Bearing
WBLT:	Weight-Bearing Lunge Test
WU:	Warm Up
YBT-LQ:	Lower Quarter Y Balance Test

Groin and Hip Complexities: Is Prevention viable?

Abstract

Groin and Hip pain is a well-recognised complaint among active young and middle-aged active adults. The groin, an anatomical region where diagnosis and symptoms are often confusing, may also represent a "Bermuda Triangle" for clinicians to disappear in vortices of suppositions and assumptions. Traditionally, there has been little International consensus regarding terminology, definitions and classification of groin pain in athletes. Consequently, there is minimal understanding of diagnosis, pathophysiology, investigation or management, although during the past decade the field has evolved and an evidence-based understanding is now emerging.

As the diagnosis is multifactorial, one of the key points is to understand the entire anatomy and most importantly, the functional anatomy. Groin and hip physical testing of impairments, function, and performance have been documented. However, many of the studies are of poor quality and the results of research difficult to interpret and implement into practice. The prevalence of Radiographic groin and hip abnormalities is considerable and requires identification of the relationship between these radiographic abnormalities and the clinically symptomatic pathologies. There is no consensus regarding the optimum conservative management or for the ideal operating technique. Further research is required in relation to nonsurgical and surgical management—and the timing of these management approaches.

The methods used in this thesis consists of drawing upon personal professional experience, attending National and International conferences, interactions at these conferences and evaluating various evidence sources. Translating and applying this ongoing knowledge into meaningful prevention and rehabilitation protocols has been practically undertaken and subsequently presented in the thesis. In spite of minimal evidence-based medicine and general lack of consensus, it seems the most pertinent point is that many of the groin/hip pathologies may be averted by an understanding of all the complexities involved.

By exploring all the knowledge (scientific and practical) of hip and groin pathologies, a prevention strategy in the first place seems plausible, with specific pre-habilitation, bearing in mind the entire kinetic chain and taking into account the neuro - motor control thereof.

Thus this thesis establishes a lack of consensus and a need for a robust hip/groin injury and pain prevention strategy.

Thesis – "Groin and Hip Complexities: Is Injury Prevention viable?"

Introduction to the Thesis

As a sports physiotherapist for the past 29 years and working in all different sporting areas, I have had the opportunity to observe the complexities of different injuries which may be related to one particular sport. My professional journey has advanced from grass root sport to elite sport such a National rugby, hockey, surf lifesaving, cricket and more. Having spent 5 years working 7 days a week with the Super 14 rugby team, it was an opportunity to analyse all specific movements and resultant possible injuries. Subsequently, I have been working with 20 Premier League Football clubs for the past 13 years which led towards undertaking the Doctorate on groin and hips. This was due to the fact that these injuries are far too frequent and my belief is that this is most definitely preventable.

Groin injury is the fourth most prevalent injury in field-based sports that include agility such as football (Ryan et al., 2014 and Werner et al., 2009). It is the most frequently reported overuse injury and the adductors are the second most injured muscles after hamstring injury in male professional football players (Werner et al., 2009). The groin injury burden is substantial, as the incidence and risk of chronicity and recurrence is high and leads to reduced performance, time-loss and may cause the end of an athlete's career.

The intricacies of groin and hip pathologies in sports is currently of international concern prompting top specialists and researchers to engage in an attempt to obtain an International consensus (Griffin et al., 2016 and Lange et al., 2015).

The systemic approach undertaken in this thesis, addresses the complexities of the groin and hip pathologies and includes different evidence sources such as personal professional experience, attending National and International conferences, and peer-reviewed evidence. This, together with the expert advice I continuously sought and received from a range of experts, assisted me in my journey to find a solution. Every portion of information gained was analysed thoroughly and then put into practice accordingly. Thereafter, this was intensely analysed in lieu of the outcome and the benefits of the intervention, or otherwise. Thus my management of groin and hip pathologies experienced by my athletes gradually changed over these years and although anecdotal, I definitely observed a positive outcome with my patients with groin /hip problems. I have also used this newfound knowledge to train sportsmen and women to strengthen the pelvis/groin/hip area very specific to the functionality of the sport as a prevention strategy. I have seen positive outcomes, but studies are required to validate this perception.

I have given many presentations in UK, India and South Africa and this ultimately led towards the structure of this Doctoral thesis. The materials and methods of my analysis in this professional Doctoral thesis is based on slides used in my CPD presentations to all levels of medical personnel, from sports physiotherapists to sports physicians, orthopaedic surgeons and hip surgeons. Since 2016, I have also been giving presentations to Coaches mostly in disadvantaged communities in South Africa. For these coaches (or managers or athletes), I believe it is also important to change the perception of “injury prevention," to a perception of "performance enhancement" when discussing this important topic. This has always been the title of my talks/workshops related directly to prevention of injuries and certainly has the attention and compliance of the coaches, as they are particularly interested in performance rather than a preventative strategy.

In this thesis, relevant slides have been chosen from these presentations and although there are many slides in this thesis, when presenting, I use specific slides relevant to the attendees present.

The presentations and this thesis are a combination of clinical experience working as a physiotherapist, the accumulation of academic knowledge in this area through journal articles and my attendance of numerous major conferences where world leading experts on groin and hips present their latest findings. In 2012 while working with Premier League Football, I compiled the Groin and Hip Handbook requested by the Premier League medical personnel (having done 2 prior handbooks on knees). This consisted of 239 of the latest International studies and “bullet points” from 12 top International specialists. While preparing this handbook it became evident that there was a lack of international consensus regarding the diagnosis and management of groin pathologies. As my interpretation is that many groin and hip injuries are preventable, I am very passionate about sharing all the latest information and possible solutions with all my colleagues.

This thesis aims to show the importance of a preventative strategy, which is imperative in reducing the incidence of hip and groin injuries. There is limited evidence for evidence-based prevention strategies or successful implementation of such programs. This thesis explores how the design of an appropriate prevention strategy should be based around a sound appreciation of the anatomy and functional anatomy of the groin and hip which in turn influences injury aetiology. A further aspect of successful prevention is appropriate screening of all players to identify any possible biomechanical abnormalities or mal-adaptations and design the prevention strategy accordingly. The successful implementation of this requires time, expertise and resources.

Further, the thesis aims to integrate opinions and practices of practitioners and my own personal experience dealing with many elite sports, supported with scientific evidence. Clinical decisions must also consider ethics and individual needs and personalities of the athletes (Greenhalgh et al., 2014). Marshall (2014) stated the need for a stronger commitment to embed academic expertise with clinical care. Further, current practice needs to inform future research studies to ensure relevant, practical outcomes. Delahunt et al. (2015) proposed a set of minimum reporting standards based on best available evidence to be utilised in future research on groin pain in athletes and that adherence to these minimum reporting standards would strengthen the quality and transparency of research and allow an easier comparison of outcomes across studies in the future.

Thus the ultimate aim of this thesis is to produce a document upgraded from my original handbook and to present a critical summary of clinical expertise and research to provide practical guidelines for the assessment and management of groin injuries.

Thesis objectives:

1. To find a viable solution to the complexity of groin and hip pathologies in sportsmen and women by providing practical guidelines for the assessment and management of groin injuries. This, after pursuing all avenues of knowledge – research, conferences, Specialist's knowledge and my practical experience.

2. To reflect on the practical journey through my professional career and analyse the hip and groin injuries in different sports and the consequential management difficulties encountered.

3. To assess whether an analysis of formal and informal knowledge can be applied to improve and develop novel injury prevention approaches and consequentially share my findings with

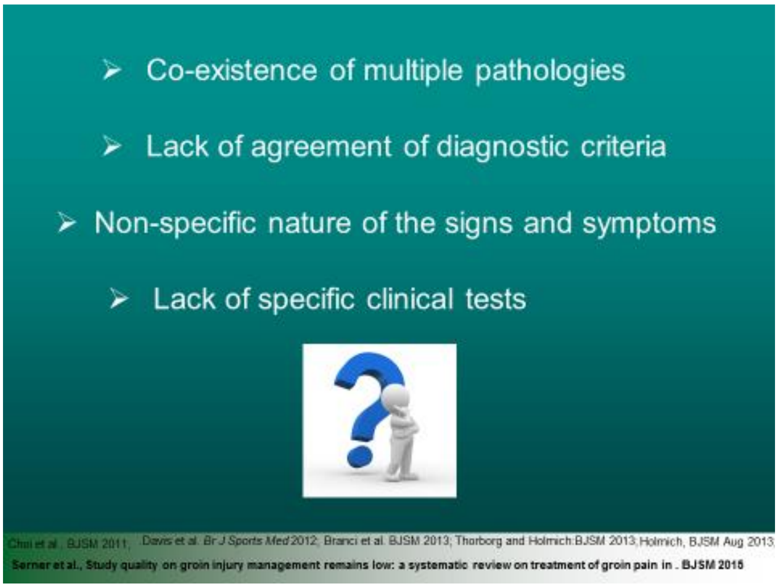
my medical colleagues to be useful practically in the sports domain.

4. For this thesis to be useful for future applications of my findings and thus the impact of my research in the professional field e.g. giving presentations to coaches from recreational to professional sport. This may give them an understanding for preventing groin and hip injuries and I believe, thus enhancing performance.

5. To make recommendations for future research with applied practical application.

The thesis is based on the Power-Point Presentations that I give on this topic and also critically evaluate the plethora of information that goes into the development of each slide. Further, my aim is to continue to give presentations and workshops which may inform and guide the relevant practitioners in reducing and managing groin and hip pain, prevention being the key component.

Slide 1



Slide 1 demonstrates clearly that hip and groin injuries are complex and difficult to treat. The main complexities include co-existence of multiple pathologies, lack of agreement of diagnostic criteria, the non-specific nature of the signs and symptoms and lack of specific clinical tests. The evaluation and treatment of groin and hip pain in athletes is further challenged by a complex anatomy and multi-factorial aetiology.

Slide 2

Bizzini (2011) described the groin area as “the Bermuda Triangle of Sports Medicine”. However, Sebecic et al. (2014) stated that if a chronic groin pain is carefully diagnosed using detailed history taking, physical examination and correct imaging techniques, treatment is successful and swift and need not be a Bermuda Triangle. However, to date, groin pain has been shown to cause time loss for one in five players in men’s professional football league each season (Mosler et al., 2018) (Slide 2).The objective of this thesis is that in spite of all the complexities, I endeavour to translate my own and specialists’ hip and groin expertise into novel rehabilitation and injury prevention strategies and to assess whether an analysis of formal and informal knowledge can be applied to improve and develop current injury prevention approaches.

Chapter 1: Introduction to Groin and Hip Quandaries

Groin and hip quandaries are due to the dilemma and confusion related to the complexity of pathophysiology, injury definitions, multifactorial causes, the lack of specificity of tests, non-consensus regarding surgery and rehabilitation and altogether the different management approaches. These factors are well expressed in ongoing research (Beddows et al., 2020; Esteve et al., 2019; Pålsson et al., 2020; Via et al., 2020).

Slide 3

Slide 3 demonstrates the specific demands on the groin and hips with high intensity activities such as turning, kicking, twisting, acceleration and deceleration involving both hip adduction and abduction in a number of sports (Ayeni et al., 2014; Chang et al., 2009; Hagglund et al., 2009; Stull et al., 2011; Thorborg et al., 2018).

Table 1: Studies to show groin and hip pain in different sports.

Sport	Incidence of Injury	Author
Ice Hockey	It has been reported that the incidence of FAI may have been under-reported in ice hockey players because of its misdiagnosis as hip or groin strains. Adductor strains accounted for 10% of all injuries in elite Swedish ice hockey players and 43% of all muscle in elite Finnish ice hockey players. Men's ice hockey has the second-highest rate of hip injuries, and they account for 18.2% of all injuries in National collegiate athletic association level ice hockey goaltenders.	Philippon et al., 2013. Tyler et al., 2001. Mehta et al., 2019.

Gaelic Football	In a case series of over 200 athletes with groin pain, the most common cause was hip pathology, followed by pubic symphysis injury	Glasgow et al., 2011; Nevin and Delahunt, 2014.
Rugby league,	Groin injuries account for 2–5% of all sports injuries. Ekstrand (1994), however, stated that an injury rate of up to 28% had been reported for footballers with groin pain	O'Connor, 2004.
Tennis	Anywhere between 8 and 27% of injuries are to the pelvis/hip/ groin in high level tennis players	Safran, M. 2014.
American Football	Injuries to the hip account for approximately 10% of all injuries in football.	Feeley et al., 2008.
National Hockey League	Hip labral tears are the most frequently encountered intra-articular hip injury in the NHL player and can lead to an average of 8 man-games missed per injury. Goaltenders were not at higher risk when measuring injuries per hours played but were at significantly greater risk of an intra-articular hip injury than other on-ice players when measured per game played.	Epstein et al., 2013
Rugby Union	Groin injuries account for 2–5% of all sports injuries and are among the top six most commonly cited injuries in Rugby Union. The prevalence of these injuries has increased since 2002 and they have moved from 16th to 4th place in most common training injuries in the Rugby Football Union annual audit.	Ryan et al., 2014.
Football Football and Ice Hockey	Groin injuries represent a considerable problem in male football, accounting for 4%–19% of all timeloss injuries. At the elite level, approximately one in five male players incur a groin injury causing time loss each season. Groin pain has been particularly reported in sports such as football and ice hockey, where approximately 10 to 20% of all injuries are hip and/or groin injuries.	Haroy etal., 2018 Thorborg, K. 2014.
Running	The incidence of hip injuries from running depends on many factors, but the average recreational runner who trains steadily and races occasionally, has a yearly injury incidence rate between 37% and 70%.	Paluska, S. 2005.
Hockey	Injuries to the groin region are a common problem in field hockey, with a reported incidence rate of 10 -12%	Beddows, T. 2020.

Further studies describing this high incidence in sport include Engstrom et al., 1991; Simonet et al., 1995; Ekstrand and Hilding, 1999; Hawkins and Fuller, 1999; Orchard et al., 2000; Grote et al., 2004; O'Connor, 2004; Arnason et al., 2004; Ellenbecker et al., 2007; Holmich et al., 2007; Hagglund et al., 2009; Werner et al., 2009; Lara et al., 2013 and Sedaghati et al., 2013.

Most of these studies concur with the fact that the prevalence of groin injuries in athletes is recognized as one of the most difficult problems in sport and is a common and debilitating injury that accounts for anything from 2–28% of all sports injuries (depending on a particular study and specific sport).

As I have been involved in most of these sports at school, club, provincial and national level, I have been concerned by the lack of focus, research and education on the groin and hip area in the past. The quandaries of hip and groin pathologies include the complexity of multifactorial causes, the pathophysiology, the aetiology and the lack of consensus regarding rehabilitation has not been sufficiently explored in the past. This has fortunately been taken into consideration over recent years with my observation of the management of hip and groin showing slow improvement, particularly with more studies evolving, as demonstrated in my reference section.

Groin and hip injuries are common in football with prevalence rates reported to be up to 19%, with the incidence rates being 0.2–2.1 per 1000 playing hours for men (Walden et al., 2015). Recovery from groin injury has been shown to take at least 1 week in 40% of cases, and 10% take more than a month (Holmich, 2007). When groin pain lasts for more than 2 months, it is said to be longstanding (Holmich, 2007). Langhout et al. (2018) stated that each season, up to 19% of all professional soccer players sustain a time-loss groin injury with an average time loss between 15 and 20 days and more than 28 days for recurrent groin injury. Of note is a systematic review demonstrating that adductor or groin injury is particularly problematic due to the high incidence and risk of chronicity and recurrence (Whittaker et al., 2015).

Sports with particularly high incidences of groin injury include ice hockey and the football codes and there is variation by player position for rate of groin injury in many sports. In Australian Rules Football they are the second most common injuries behind hamstring muscle strains and have been estimated to be responsible for 11-18 competition games per team being missed by players due to injury in a season (Orchard et al., 2015). In male professional footballers, muscle injuries constitute almost one third of all time-loss injuries, while 23% of those injuries involved the adductors. There is clearly a high incidence of hip and groin injuries which account for a large number of missed competition days (Orchard et al., 2015). Previously, Hanna et al. (2010) reported that 70% of male soccer players experience hip and/or groin pain during one season and Ryan et al. (2014) stated that these injuries were among the top six most commonly cited injuries in Rugby Union and they have increased significantly since 2002 moving from 16th to 4th place in the 2012 Rugby Union annual audit.

Slide 4

Table 1 Comparison of US collegiate pelvis/hip muscle/tendon injury rates for 15 sports

Sport	Game: % of injuries	Game: IR per 1000 AE	Practice: % of injuries	Practice: IR per 1000 AE
Men's soccer[11]	3.9	0.74	7.8	0.34
Men's ice hockey[12]	4.5	0.73	13.1	0.26
Men's American football[13]	1.9	0.65	5.2	0.2
Women's ice hockey[14]	4.2	0.53	12	0.3
Men's lacrosse[15]	3.3	0.41	5.6	1.8
Women's soccer[16]	2.2	0.37	7.6	0.4
Men's wrestling[17]	1.1	0.28	<1	<0.05
Men's basketball[18]	2	0.18	4.4	0.18
Women's gymnastics[19]	1.2	0.18	2.7	0.17
Women's lacrosse[20]	2.3	0.16	5	0.16
Women's field hockey[21]	2.8	0.15	9.9	0.25
Men's baseball[22]	2.6	0.15	2.5	0.05
Women's volleyball[23]	2.5	0.08	5	0.14
Women's softball[24]	1.3	0.05	2.9	0.08
Women's basketball[25]	<1	<0.07	3.2	0.13

Orchard, J. W. Men at higher risk of groin injuries in elite team sports: a systematic review. BJSM. 2015.

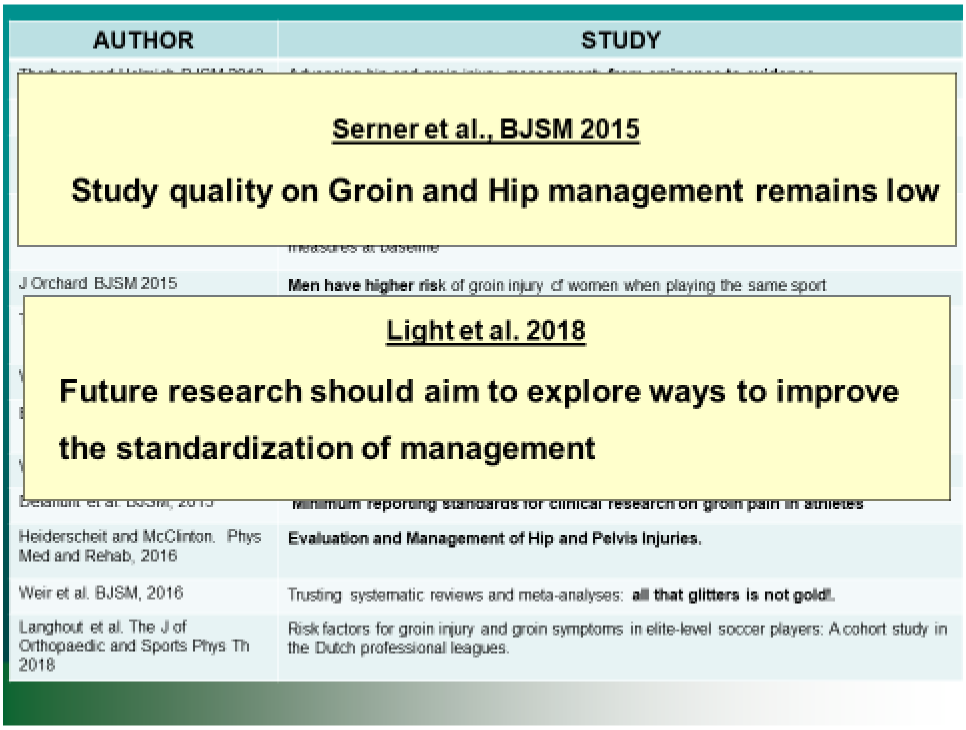
There is some evidence that men have a higher risk of groin injury than women when playing the same sport (Orchard et al., 2015 and Walden et al., 2015) (Slide 4). Orchard et al. (2015) recommended that injury epidemiology consensus statements should aim to include a number of relevant sports to improve injury incidence comparisons among different sports.

Groin pain is most commonly related to the adductor muscles, pubic symphysis, inguinal region and nerve supply to the groin (Minnich et al., 2011). As a consequence of such an injury, the athlete may be out of play for a lengthy period, possibly resulting in major financial implications for the Club and the player (Bennell et al., 2014; Economopoulos et al., 2013; Matheson et al., 2011; Minnich et al., 2011; Muschaweck and Berger, 2010; Pierce et al., 2013; Spencer-Gardner et al., 2013). I have noted in my work with athletes that a number of these groin and hip injuries may become chronic and in some cases may even be career ending. This is probably due to the fact that very often these injuries and the consequential pain is minimal and then becomes progressively worse with different anatomical structures becoming involved. This is key to the importance of analysing the complexity of the problem of groin and hip pathologies.

Thus with this ongoing, often debilitating injury, it is most important to prevent the pathology from developing in the first place. As will be discussed in Chapter 10 (Risk Factors), understanding possible risk factors for the players in specific sports is the key factor for this prevention strategy.

The definition of groin pain is broad and vague. Research provides no consensus on pathology/pathophysiology (Thorborg and Holmich, 2013). Heterogeneous studies with low methodological quality dominate research related to groin pain in athletes (Delahunt et al., 2015). In this study they explained that the key items for inclusion were based on the collective expertise of the group along with analysis of key methodological shortcomings of published research in the area, identified by recent systematic reviews. They advise a minimum reporting standard in relation to: (1) study methodology, (2) study participants and injury history, (3) clinical examination, (4) clinical assessment and (5) radiology. They hypothesised that adherence to these minimum reporting standards may strengthen the quality and transparency of epidemiological research conducted on groin pain in athletes.

Slide 5



Slide 5 highlights the systematic review on the treatment of groin pain in athletes by Serner et al. (2015), where they identified 72 relevant studies of which they stated that only 6% of the studies were of high quality. Low methodological quality, confusion around the nomenclature of groin pain in the athlete and inadequate reporting were highlighted in this review. Light et al. (2018) re-affirmed that standardization of management needs to be explored in future research. There was moderate evidence for the efficacy of conservative treatment (active exercises and multimodal treatments), as well as moderate evidence for surgery for athletes with adductor-related groin pain or sportsman's hernia.

Slide 6

Slide 6 shows the discussion at the 1st International Hip and Groin Conference in Aspetar, Doha in October 2014, whereby Holmich confirmed that to date there was no pathophysiological correlation to pain; no imaging correlation to pain and no reliable operational findings correlated to pain. It was further suggested at the Doha Conferece (2014) that there was a need to provide minimum methodological and clinical reporting standards for research on groin pain in athletes.

Previously, Weir (PhD thesis, 2011) found that the interpretation of hip and groin research was limited by differing nomenclature, lack of validated outcome scores, unreliable clinical tests for core stability and differences between case series and prospective studies. Despite increasing research over the past 20 years, the hip and groin quandary exists to this day. Forty years ago, Renstrom (1980) reported that groin pain (which was inclusive of hip pain) was a challenging pathology and little has changed to date. From my experience with many elite sports, I have observed that until recently, groin and hip pathologies have not been given priority when managing injuries in sports medicine. As will be discussed later in the thesis, the International meetings to obtain Consensus Statements on the nomenclatures have been fruitful. However, this is an ongoing procedure and more specificity is required on an ongoing basis, such as providing better specific clinical tests.

Conclusion – Introduction to Groin and Hip Quandaries

Despite the large number of published papers on hip and groin pathology, the literature continues to show conflicting results as is evident throughout this thesis. If clinicians did indeed take cognisance of these high profile evidence based medicine studies, they would realise the lack of definitive strategies. This is often reflected in the wide spectrum of diagnostic criteria and treatment regimes proposed by clinicians. There is still no obvious consensus or solution and there is no observed decrease in the number of hip and groin injuries in sportsman (Hernia Surge Group, 2018; Kemp et al., 2018; Mellor et al., 2016; van Klij et al., 2018).

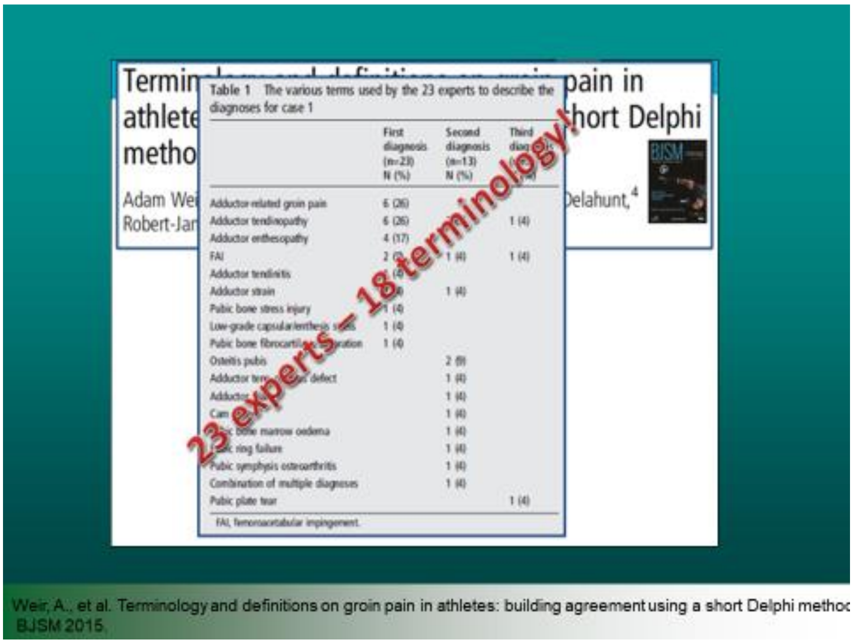
Future research on groin pain in athletes, using established published guidelines to improve study methodological design and reporting, may be productive and a consensus document needs to be drawn up by experts which may provide these guidelines. Essentially, I believe that a panel of experts are required to meld the research findings with their practical experience out in the field. It would be ideal if all this could be standardised which is complex, as every situation is different. I believe that the potential impact of this thesis on development of knowledge in the professional field is plausible and thus my presentations may have impact for clinicians to reconsider and anlyse their management of hip and groin problems.

Consequently, it appears that a preventative strategy may be the key to prevent the injuries from occurring in the first place.

Chapter 2: Differential Diagnosis

2a) Overview

Slide 7

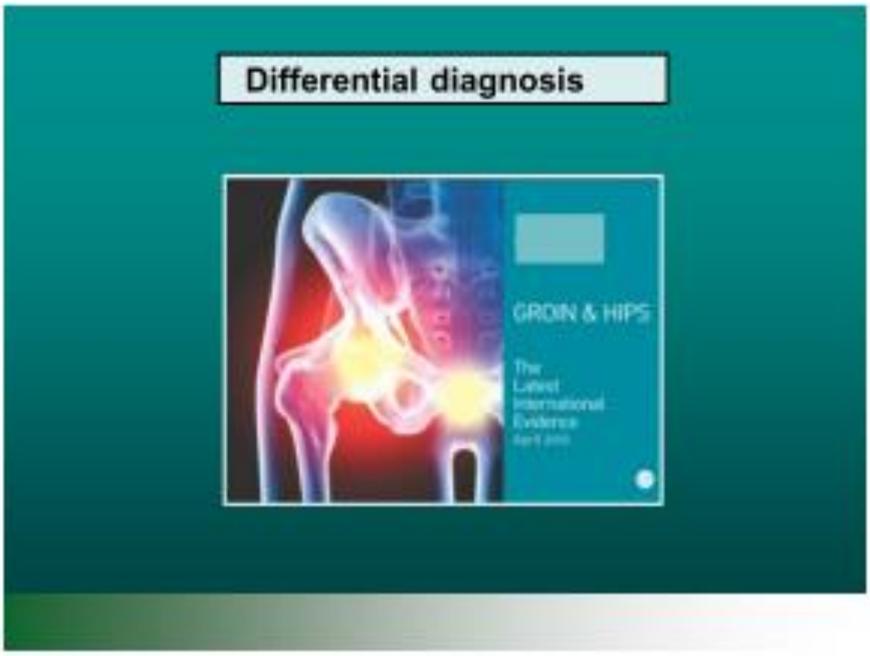


A presentation by Weir (Isokinetic Conference, 2015), was based on his work on the terminology and definitions on groin pain in athletes (Slide 7). His main finding was that the 23 expert Specialists used 18 different terminologies. Thus, in spite of groin and hip pain being common in many sports, the definition of groin and hip pain is problematic as the pathologies are so multifactorial and there is a great need for consensus surrounding the terminology (Minnich et al., 2011). This was affirmed by Thorborg and Holmich, (2014) who stated that there was a disparity in terminology used across the world.

During the evaluation of a patient with groin pain, clinicians often focus on a single etiological cause without considering the possible association of multiple causes. Amongst others, there is adductor-related groin pain, (Chen et al., 2014; Coughlan et al., 2014; Delmore et al., 2014; Holmich et al., 2013; Jensen et al., 2014; Schilders et al., 2009; Thorborg et al., 2011), osteitis pubis, (Brennan et al., 2005; Choi et al., 2011; Cunningham et al., 2007; McCarthy and Vicenzino, 2003; Robinson et al,. 2007; Verrall et al., 2007), sports hernia, (Antoniou et al., 2014; Garvey et al., 2010; Knox and Berney, 2015), Gilmore's groin, (Williams and Foster, 1995), incipient hernia, groin disruption (Garvey and Hazard, 2014) and athletic pubalgia (Kuikka et al., 2013; Larson, 2014; Meyers, 2008).

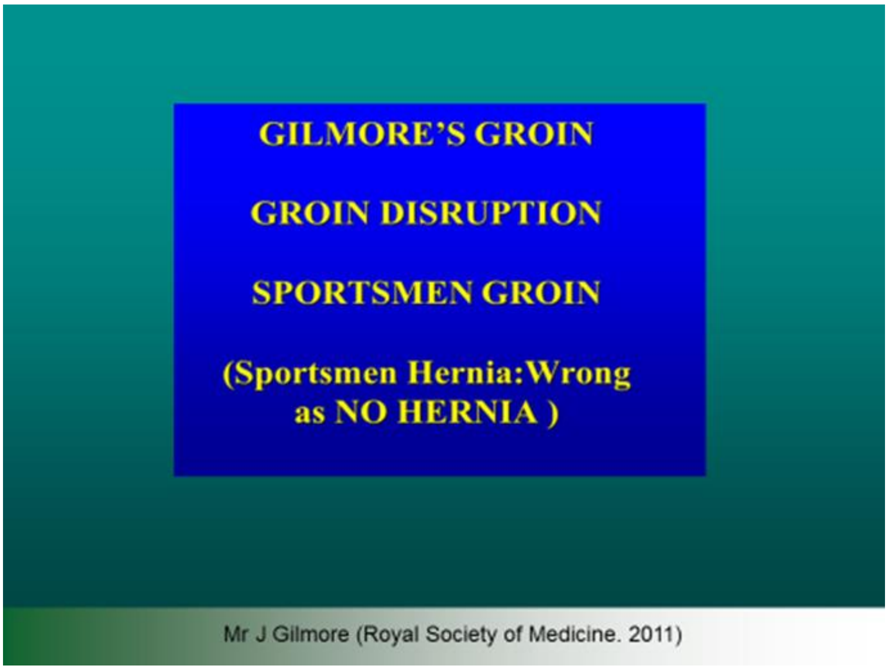
There is general consensus in the academic literature that multiple pathologies can co-exist in patients with chronic groin pain (Garvey and Hazard, 2014; Zoland et al., 2017). Of note is the observation of Rankin et al. (2015) who showed that hip joint pathology may be a major contributor to secondary breakdown of adjacent structures around the hip joint. Advances in Magnetic Resonance Imaging (MRI) and hip arthroscopic surgery provide insights which appear to suggest that earlier studies may have overlooked the hip joint as a source of primary pain in the athlete (Byrd and Jones, 2001; Malviya et al., 2012).

Slide 8



Slide 8 shows the literature review I undertook specifically for the Premier League medical personnel, which identified multiple differential diagnoses for hip and groin pain, including musculo-skeletal and non musculo-skeletal causes such as infectious, tumerous, metabolic causes, genito-urinary and gynaecologic causes, inflammatory conditions and metabolic causes (Millson, 2012). Many different management strategies were prescribed and this was highlighted in the handbook by the “bullet points” collecting from eminent International specialists with regard to management principles. There is a wide spectrum of approaches to both the diagnosis and management of hip and groin injury. This speaks to the complexity of pathology in this area, but also highlights an urgent need for uniform agreement internationally on best practice when dealing with these pathologies. This is a major reason for my embarking on this pathway to find a solution in the management of groin and hip pain. The impact of my handbook exceeded expectations in that it reached a far wider field than the Premier League. There was a demand frommedical personnel nationally and internationally

Slide 9



An example of this complexity of diagnoses is the use of the term "Gilmore's Groin," which has been applied over the past 30 years as shown on Slide 9 (Gilmore 1998). During ensuing years there have been discussions and challenges as to the exact terminology and meaning behind this name (Williams and Foster, 1995).

Holmich (2014) concluded that a systemic approach, based on standardized clinical examination using reliable examination techniques and well-defined clinical entities is very important to diagnose and plan the correct treatment for footballers with groin pain. Critically, diagnostic and rehabilitation strategies aimed at and designed towards treating single pathological anatomical entities are likely to be limited.

Table 2: Differential Diagnosis for groin and/or hip pain

Author / Journal	Commentary on diagnostic classifications
Holmich, 2007.	There are 3 musculo-tendinous causes for chronic groin injury in sportsmen – a **"clinical entity"** approach, involving Hip adductor-related dysfunction , IP related dysfunction and RA related dysfunction
Caudill et al. 2008.	Between 27% and 90% of athletes with sports hernia type symptoms have **multiple pathologies** - Four broad categories: (1) adductor longus dysfunction; (2) OP (3) sports hernia and (4) a pathological condition of the hip joint.

Meyers et al. 2008.	The term **"sports hernia"** was felt to convey two huge **assumptions** regarding groin injuries. Firstly, that the cause of the injuries has something to do with occult hernias and secondly, that the injuries can be lumped into one explanation and be treated the same way.
Falvey et al. 2009.	A patho-anatomical approach to the diagnosis of chronic groin pain in athletes. **The Groin Triangle:** The groin, gluteal and greater trochanter triangles. Groin injuries were classified according to anatomic position and not specific to structure. This is used frequently in current practice
Garvey et al. 2010	An algorithm **showed a pathophysiology for sports hernia** with certain pathologies leading to pelvic instability which then results in further pathologies of the groin and hip.
Tunaiji H.A. and Karim Khan. 2012.	This study discussed the causes of chronic groin pain in relation to different borders of the Groin triangle showing **"Common, Less common and Not to be Missed" pathologies in tabulated form.** This approach addresses anatomy complexity and clinical diagnostic challenges of the groin region.
Poultsides et al. 2012	The study demonstrated an **algorithmic approach to physical examination** of a painful non-arthritic hip. Underlying abnormal joint mechanics may predispose the hip joint and the associated hemipelvis to asymmetric loads and thus possibly mal-adaptations.
Brukner and Khan. 2012	**This study discussed a structure based diagnosis on four clinical entities that may be involved in LSGP**. The hip joint was not included in this particular definition. This was the closest to the subsequent Doha Consensus agreement (2015).
Garvey and Hazard. 2014.	Diagnoses included RA muscle atrophy/asymmetry, conjoint tendinopathy, sports hernia, groin disruption injury, classical hernia, traumatic OP and avulsion fracture of the pubic bone. The authors believed that AP or sports hernia should be considered as a '**groin disruption injury'** as **previously described by Gilmore and is a result of functional instability of the pelvis.**
Jayasekera et al. 2014.	These authors described a new, previously undescribed diagnosis of **fat pad entrapment** at the hip. They proposed that this fat pad found at the anterior head /neck junction of the hip joint can be a source of pain.
Muschaweck et al. 2015.	The anatomical and functional complexity of the groin was recognised. In addition **radiating pain from remote anatomical regions** was added as possible differential diagnoses.
Bisciotti et al. 2015.	Multifactorial aetiology of groin pain syndrome was acknowledged. These authors specified that **"groin pain" means "pain in the groin area" and is not a diagnosis.**
Wisbey-Roth, T., 2015.	It was suggested that a Hip Differential Diagnosis Flowchart should be utilised, showing **five categories for assessment strategies** – Inflammation, Instability, Intra-articular, Extra Articular and Tendon
Serner et al. 2015.	A systematic review reported **33 different terminologies used in 72 studies** for the diagnosis of hip and groin pain
Weir et al. 2015	A study using a short Delphi survey of two 'typical, straightforward' cases demonstrated **major inconsistencies in the diagnostic terminology used by experts** for groin pain in athletes
Bisciotti et al. 2015.	They discussed an association between inguinal canal disease, like sports hernia and FAI, to redefine and expand the concept of **"groin pain disruption".** In this study, they referred to the groin pain as GPS.
Falvey et al. 2016	This was part 1 of a study to show a prospective anatomical diagnosis. Injury to the pubic aponeurosis (PA) (62.8%) was the most common diagnosis, followed by injuries to the hip (21.2%) and adductors (14.7%). **Nearly two-thirds of patients (63.6%) demonstrated pain and abnormality in multiple anatomical structures**.

IP: Ilio Psoas; RA: Rectus Abdominus; OP: Osteitis Pubis; LSGP: Long Standing Groin Pain

AP: Athletic Pubalgia; GPS: Groin Pain Syndrome

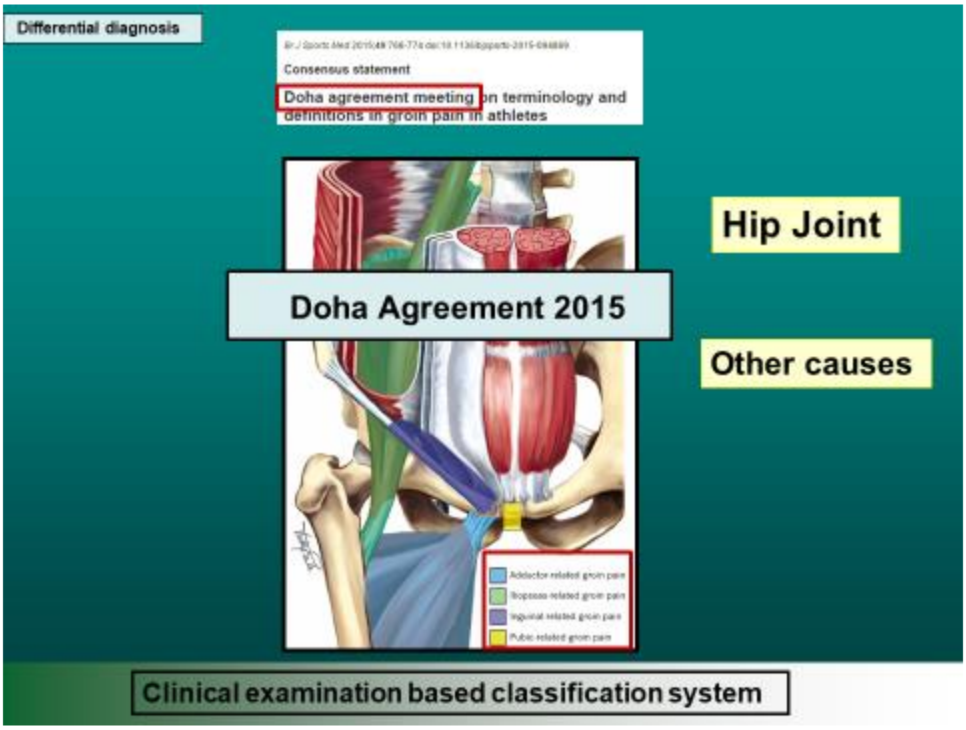
Table 2 demonstrates that there is a wide spectrum of approaches to the diagnosis of groin and hip pathologies over years. These different terminologies and overlapping entities make the diagnosis and subsequent management for all clinicians complex. However, this thesis is deigned to demonstrate the fact that even without a specific diagnosis, rehabilitation is possible, as I have noted in my professional career. This is particularly so over the past years when undertaking this thesis and increasing my knowledge of groin and hip pain and thus more successful management.

Some progress was made when Sheen et al. (2014) issued a British Hernia Society Consensus statement regarding treatment of Sportsman's groin where they attempted to narrow down a more definitive terminology. The term 'inguinal disruption' was chosen as the preferred nomenclature with the term 'Sportsman's hernia' rejected, as no true hernia exists in these pathologies. They proposed that it should be managed through a multidisciplinary approach to ensure that consistent standards and outcomes are achieved. This multidisciplinary approach is often identified as important in the management of hip and groin pain and was frequently mentioned during the hip and groin conferences in 2015 (World Conference on Groin Pain in Athletes, Doha, Qatar) and 2016 (Football Medical Association Conference, Midlands, England). The multidisciplinary approach was inclusive of Sports Physicians, Orthopaedic Surgeons, Physiotherapists, Biokineticians and all medical and fitness personnel involved with the athlete and appears to be critical for best practice.

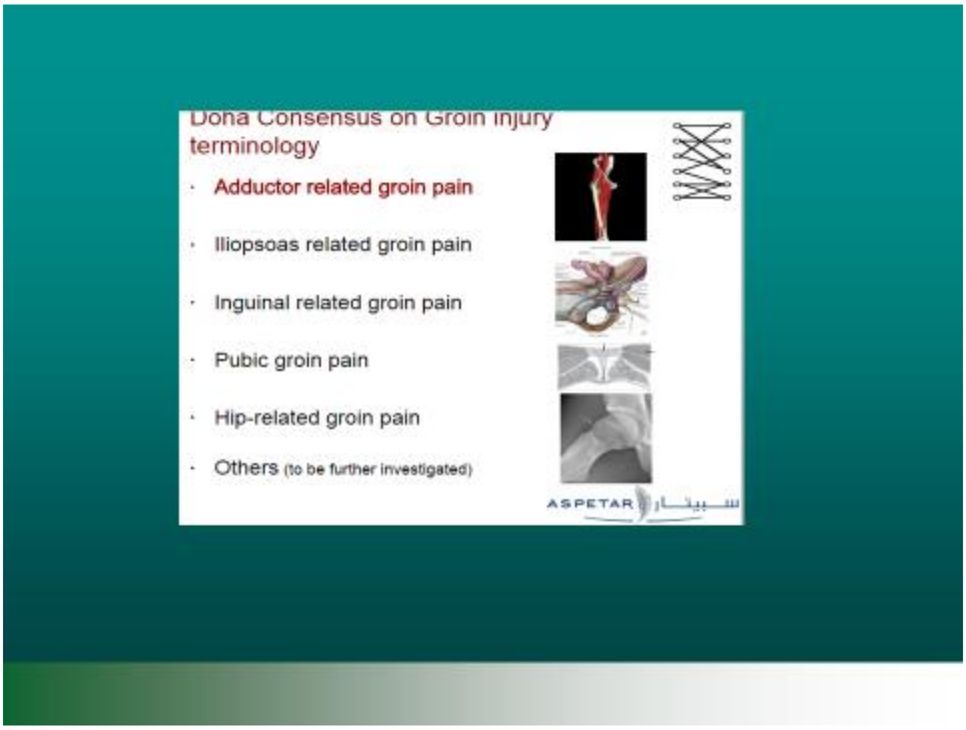
Overall, the response to the Consensus Agreement was a disappointment amongst practitioners, as there appeared to be an over-representation of surgeons. Further, "inguinal disruption" merely added to the long list of different terminologies. Thereafter, the commentary by Adam Weir in the British Journal of Sports Medicine (2014) stated that the paper gives rise to as many questions as it does answers. The statement achieved success in reaching agreement among surgeons that there is no favoured surgical method at the present time and also highlighted that there were still some significant limitations in the management of groin and hips in sports medicine. I agree with Weir who was of the opinion that a review of current evidence was needed which critically analysed and prioritised current information of differential diagnosis in hips and groins and so could stratify information according to scientific rigor. This evidence relevant to my professional field of sports physiotherapy and rehabilitation would be most helpful. Nonetheless this was an important first step on a long journey towards consensus in the field of athletic groin injuries.

Slide 10

Slide 11



Slide 12



Slides 10, 11 and 12 shows that subsequent to the Manchester Consensus Agreement, the ground breaking "Doha Consensus Agreement" meeting on terminology and definitions in groin pain in athletes was convened in November 2014, which included 24 international experts from 14 different countries. The aim of the meeting was to reach agreement on a standard terminology, along with accompanying definitions. They reached a consensus based on history and physical examination to categorise athletes, making it simple and suitable for both clinical practice and research. Unanimous agreement was reached using the classification system which has three major subheadings of groin pain in athletes as shown in the slide 11 and 12:

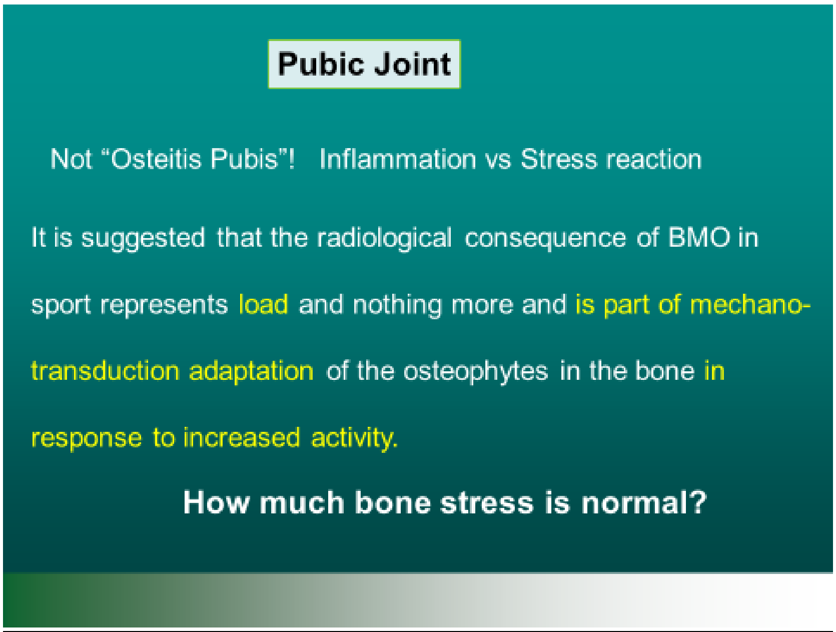
1. Adductor-related, Iliopsoas-related, inguinal-related and pubic-related groin pain.
2. Hip-related groin pain.
3. Other causes of groin pain in athletes

It was a privilege for me to attend this conference and have personal discussions and interaction with the specialists regarding their anticipated outcome. They questioned me regarding my approach to the new definition and whether I thought this was a move towards a more practical and transparent outcome in our management of sports-related hip and groin problems

Interestingly, they are renowned international groin and hip specialists and yet have an ongoing desire to make a difference to the clinicians out in the field. From my years of experience, I have noted that the relationship between specialists and clinicians is not always productive. This is probably due to the fact that they are all too busy to interact. Interestingly, once approached and once they acknowledge the clinician's passion for knowledge and sharing, they are very conducive to having discussions and sharing their insights. To date they continue to answer my ongoing questions regarding management of groin and hip problems.

This provided common ground amongst clinicians dealing with groin pain. Subsequent to the Doha Agreement, various amendments to the Doha agreement have been proposed, as well as various valuable practical applications have been undertaken based on this classification. In an introductory letter in the BJSM, Holmich (2015), concurred that the Doha agreement was an important step forward by proposing basic terminology for all to speak the same language and hopefully improve the management of groin injuries.

Slide 13

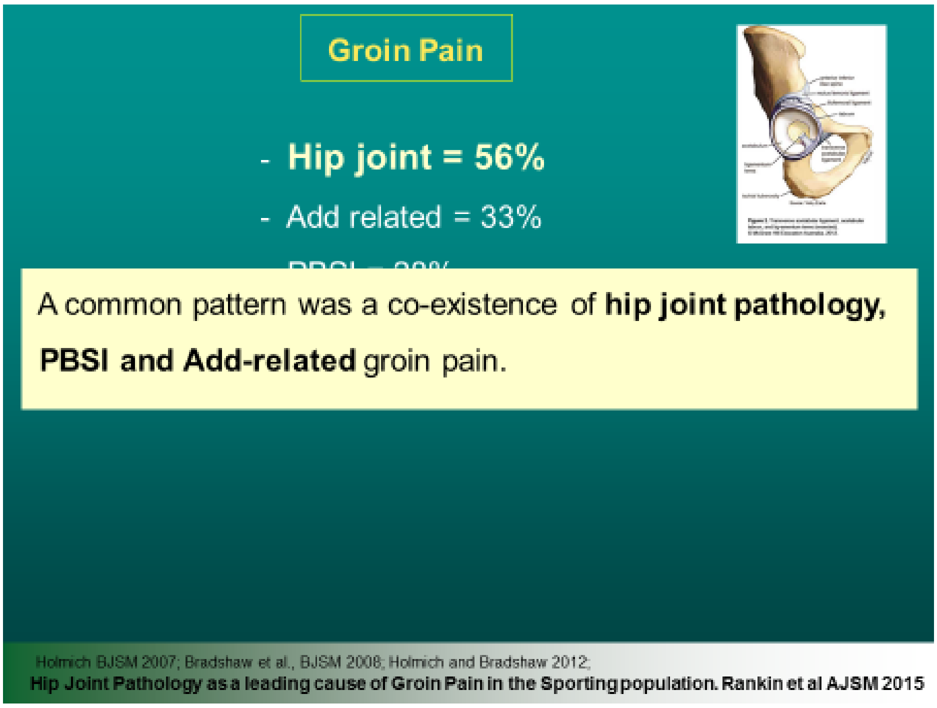


An example of this is the terminology "Osteitis Pubis" (OP) previously commonly used, is no longer utilized (Slide 13). From my years of working with Premier League football, I have noted that more than half of the Premier League footballers show increased uptake of bone marrow oedema in pre-screening / signing MRIs. However, they are mostly asymptomatic. This is postulated to be due to the radiological consequences of bone marrow oedema in sport, which is representative of mechano-transduction adaptation of the osteocytes in the bone in response to increased activity (Millson, 2012). Thus the diagnosis of “Osteitis Pubis” for groin pain which had previously been made based on MRI, has been recognised as no longer relevant as a specific diagnosis. Robinson et al. (2015) concluded that pubic bone marrow and parasymphyseal findings on MRI were frequently found in asymptomatic athletes and did not predict injury or symptom development or any need for surgery.

Most importantly, “pubalgia,” an adductor dysfunction, was a more frequent MRI finding than “Osteitis Pubis” in soccer players (Cunningham et al., 2007). The findings of this study suggest that both entities are mechanically related and that Osteitis Pubis and adductor dysfunction frequently coexist and thus adductor dysfunction most likely precedes the development of Osteitis Pubis in soccer players. The difficulty which is apparent at specific conferences on this topic, is that as a clinician, one does not know when the increased bone marrow oedema shown on the MRI becomes symptomatic, or how one can predict the pathology of either the adductor or pubic symphysis bone marrow oedema uptake. At the North East Symposium on Sports Injuries and Exercise Medicine medical meeting (5th May 2016), the panel discussion involving a Premier League doctor, an eminent radiologist and myself, resulted in a detailed discussion regarding a need for some form of grading of this bone marrow oedema with the aim of being able to identify when an asymptomatic condition may become symptomatic. However, as yet this objective has not been achieved. These are most important considerations for the prevention of groin pain and would be particularly important in the young athlete.

Holmich (2015) cited eight papers from peer-reviewed journals, published between 1997 and 2013, and concluded that a lack of randomised trials existed in this area and there was no agreement in the literature with regards to diagnostic entities and terminology. Holmich suggested the term ''adductor-related groin injury''. A well-defined clinical examination of the adductor, iliopsoas, and abdominal muscles and the symphysis joint for pain, strength, and flexibility was found to be reproducible with only limited intra- and inter-observer variation.

Slide 14

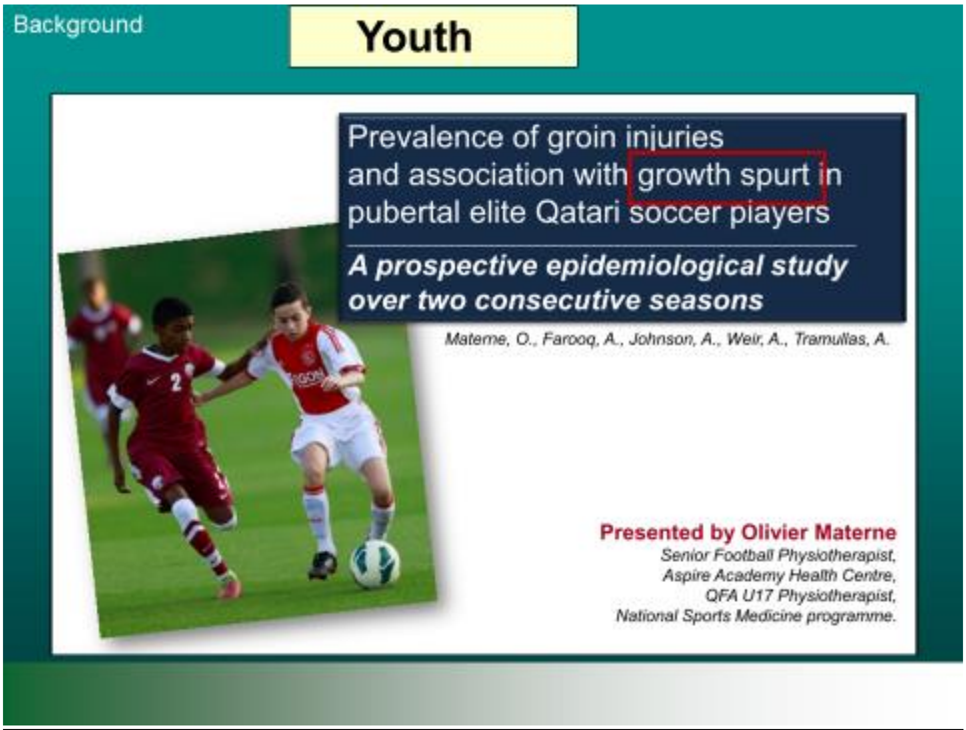


Rankin et al. (2015), reaffirmed that chronic hip and groin pain is often associated with multiple clinical entities and that hip joint pathology is the most common clinical entity of groin pain and often existed with pubic bone stress injury and adductor-related groin pain (Slide 14). He believed that hip joint pathology was related to femoro-acetabular impingement, labral tears, and osteoarthritis. Historically, hip related groin pain was often buried amongst the diagnostic criteria for the groin. These pathologies are frequently associated with secondary breakdown of surrounding structures. However, the underpinning mechanisms are unclear.

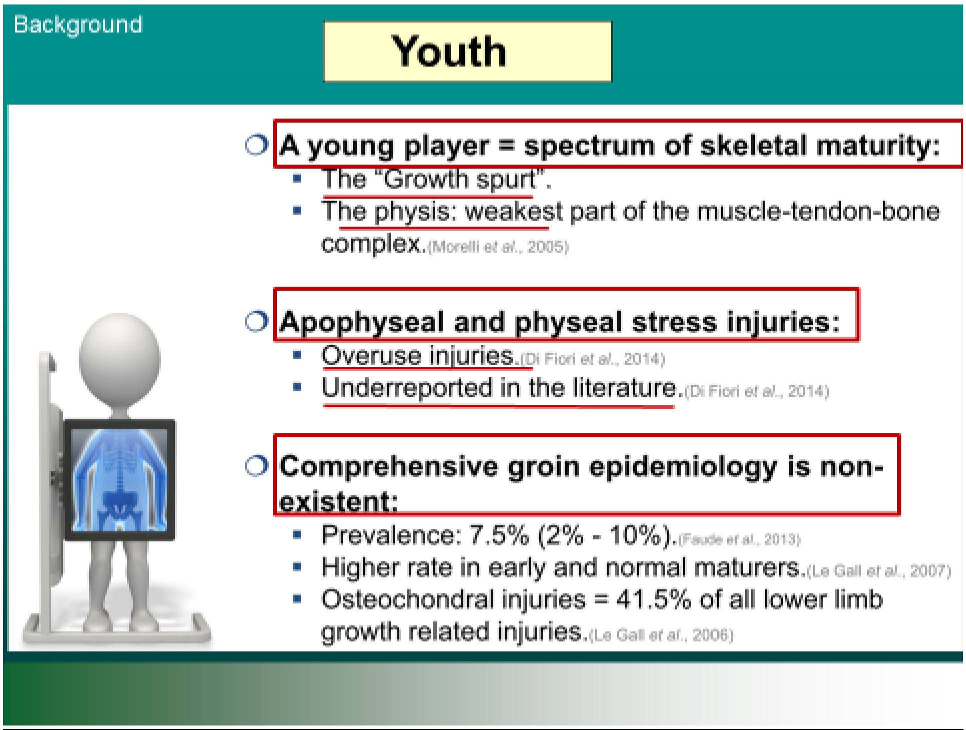
A novel overview of differential diagnosis of hip and groin pain was presented by Dr Charlotte Cowie (Football Medical Conference, Burton on Trent, Midlands, 2016). This was based on her work at St Georges Park, England where they saw 846 players from the Professional Football Association, of which 134 had long term groin problems. She divided the diagnoses into a simple group and a complicated group with multiple pathologies. The group with multiple pathologies were described as having pelvic overload. She stated that rest may settle the problems, but would not cure them. Essentially optimal loading may be defined as the load applied to structures that maximises physiological adaptation. The magnitude and the rate of loading is an ongoing challenging issue (Gabbett, 2016; Glasgow et al., 2015; Lerebours et al., 2016). The take home message was that if the clinician can return the player to normal full function (after a battery of tests and relevant rehabilitation), the pathology is not important and one should not get too focussed on a specific diagnosis. Clinically, I have used this modus operandi when managing most of the groin and hip patients over the past years with a good success rate.

From my observations in elite sports, players with groin pain often consult a number of different specialists who all give a "specific diagnosis", that often resulted in three different surgical procedures. This may simply be attributed to the complexity of making a diagnosis in hip and groin pain, but may also occur when medical staff and/or the club go for a "quick fix" in order to get the player back as soon as possible. In some cases, this varied diagnosis and management has led to the player no longer being able to compete at that elite level, which I have observed due to having an overview when gathering medical information at each club. Ongoing different pathological diagnoses, with resultant different management strategies on an ongoing basis have even led to psychological issues with the player.

Slide 15



Slide 16

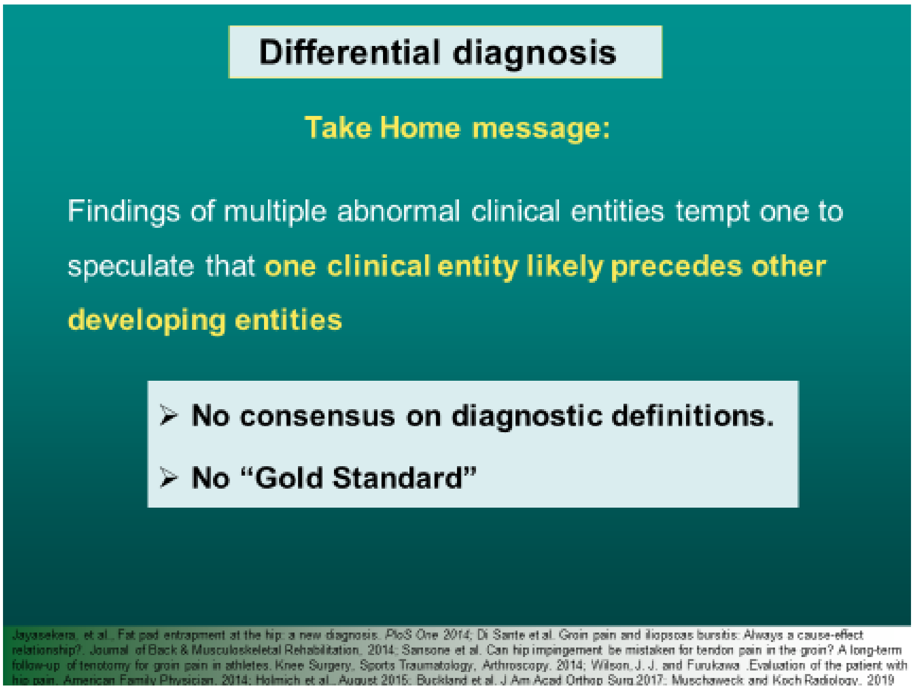


As shown in Slide 15 and 16, differential diagnosis is often easier to establish in the young athlete compared with the adult athlete. Growth related injuries are the most common risk factor for developing groin and hip pain in the young athlete (Difiori et al., 2014; Materne, 2014; Murray, 2017). Adult injuries frequently have multifactorial aetiology, have experienced pain for a longer time and may be impacted by other injuries.

Conclusion – Differential Diagnosis

The commentary by Weir (2014), noted that even though there was not a one-off solution to the nomenclature that makes diagnosis simple, the road appears to be getting clearer as the specialists in this groin and hip field are interacting. These consensus agreement meetings just confirm that no one person has the answer and without ongoing collaboration, the diagnostic dilemma with hip and groin pathology will remain static. When giving presentations, I frequently discuss the importance of collaboration with my colleagues, as I believe this factor has strengthened my knowledge and thus my implementation of management strategies with groin/hip and other musculo-skeletal problems. From my work with the Premier League Football over the past 13 years, I have definitely seen progress regarding medical interaction, with guidelines and consensus statements being implemented worldwide. The collaboration between specialists, the increase in meaningful studies and the many groin and hip conferences embracing all medical personnel, aids towards a more simplified management structure of these groin and hip problems and shows progression going forward.

<u>Slide 17</u>



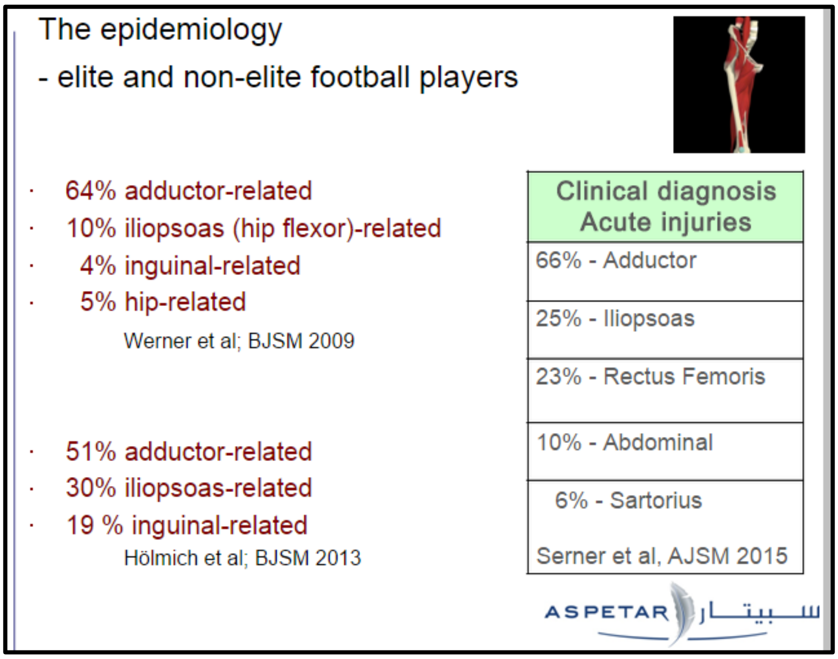
The take home message is that there is no "gold standard" for diagnosis of groin and hip pathologies, in spite of the Doha Consensus agreement (2014) (Slide 17). Internationally, there is an ongoing desire to work toward a common agreement. However, with findings of multiple abnormal clinical entities and the reduced probability of being able to identify the one clinical entity that likely precedes other developing entities, the solution to a definitive diagnostic is not straight forward. Essentially, in spite of this complexity, I believe that it is possibly to manage a groin or hip problem without a definitive diagnosis. This has been a key factor for me over these past years since undertaking the thesis. I have observed the positive outcome of my groin and hip patients despite not having a definitive diagnosis. This has involved a thorough understanding of the biomechanics and anatomical functionality of each athlete and the specific sport with which they are involved. This strategy will be mentioned in detail in Chapter 11 - (Prevention).

Chapter 3: Anatomy

3a) General

Without a clear clinical pathological diagnosis, the subsequent management of chronic groin pain is difficult. As discussed, the combination of complex anatomy, variability of presentation and the non-specific nature of the signs and symptoms make the diagnostic process problematical. This is apparent in clinical practice, where different specialist surgeons focus on a specific anatomical area and operate accordingly, as will be discussed in Chapter 7 – Surgery. I believe that the limitation in clinical diagnosis, based on patient signs and symptoms in hip and groin pain increases the importance of an in-depth knowledge of structural and functional anatomy in this area which will clearly be shown in this chapter. This may direct the clinician to understanding the functionality of the movement patterns and by assessing mal-adaptations, be able to prescribe a prevention or rehabilitation protocol, in spite of not having a definitive single diagnosis.

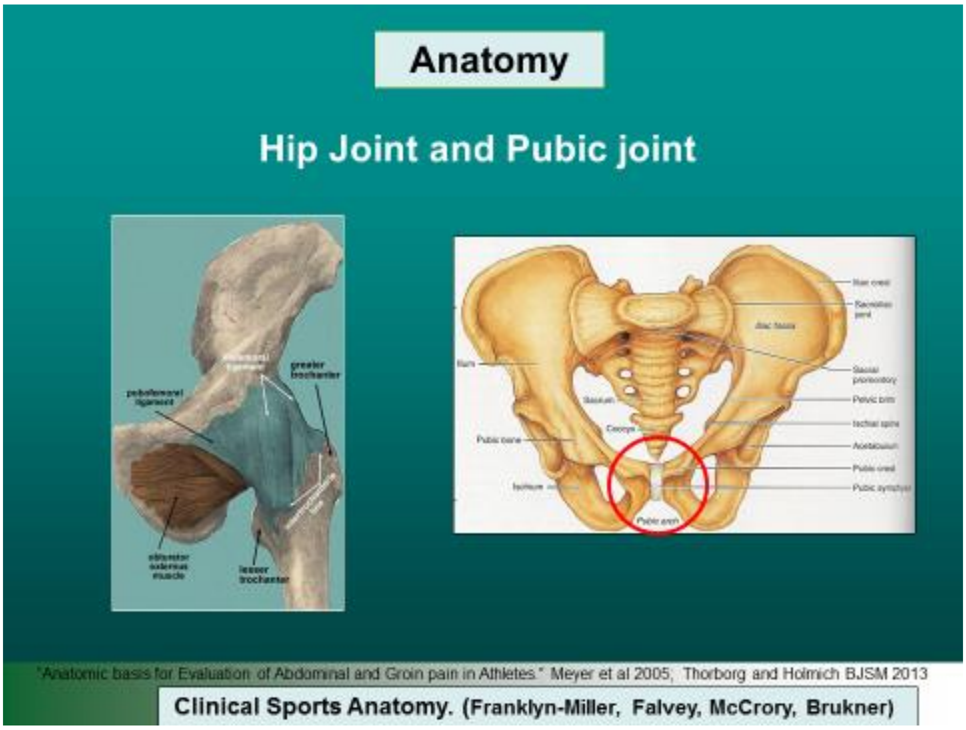
Slide 18



This understanding of the structural and functional anatomy was highlighted in a presentation by Weir, at the Doha conference (Nov 2014) and shown succinctly on Slide 18. This shows the epidemiology of elite and non- elite football players. The diagnoses are classified according to the anatomical structure implicated. A number of structures lie in close proximity to one another in a relatively small defined area of the hip and groin and an intimate knowledge of the anatomy is required to accurately identify implicated injured structures.

Holmich (2013) discussed the importance of anatomy when reporting that the muscles, tendons, nerves, ligaments and joints in the hip and groin region interact and depend on each other. In my practice, I now value that the synergies between muscles acting across the sacrolliac joints, pelvis and hip joints are essential for achieving good function of most movements that involve the extremities. From my clinical teaching experience and getting feedback from participants, I realize that functional anatomical knowledge in this area has been underestimated for years by clinicians who tend to focus on one particular anatomical area.

Slide 19



At the Football Association meeting in London (2017), Meyers stressed the fundamental appreciation of the anatomy of the groin and hip region when dealing with any groin or hip pathology/pain. He highlighted the inter-relationships between the hip and the pubic joint and described the anatomic and pathophysiologic basis for abdominal and groin pain in athletes (Meyers et al., 2007). Previously, they depicted the pelvic anatomy pertinent to the clinical problems and correlated this anatomy with a number of syndrome variants (Meyers et al., 2005)

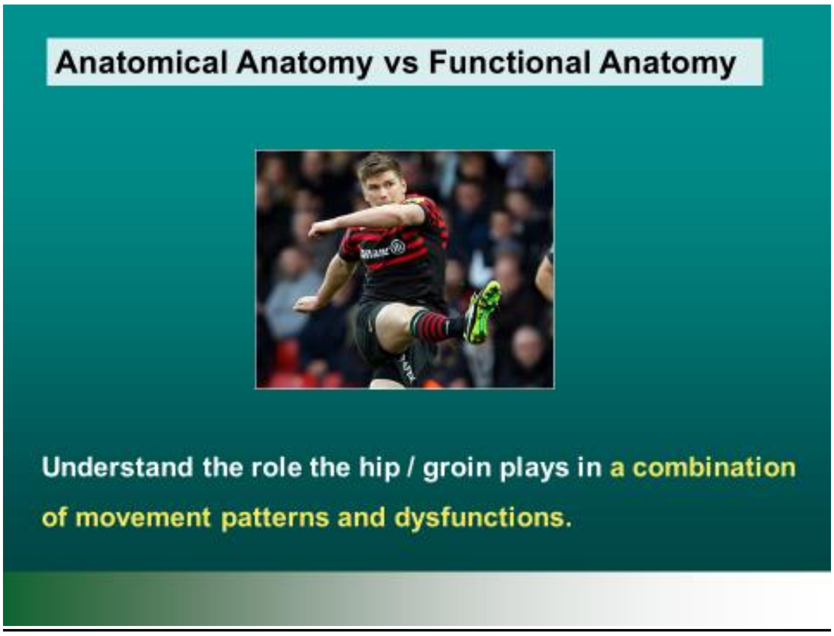
(Slide 19). Thus the emphasis was on specific structures rather than the inter-relationship between structures.

I totally concur with the authors that the concept of a “pubic joint” or “pubic dynamic complex” was the essence to understanding the anatomy and pertinent pathophysiology in groin and hip patients. Brandon et al. (2011) explained the major role the pubic symphysis plays in anchoring the anterior abdominal wall, inguinal region and the adductor group and also how the inguinal region functions as a transition zone between the torso, lower extremities and the genital area. These lessons should be at the forefront of treatment, rehabilitation and prevention of groin and hip pathologies. I now realise that we have previously underestimated the role of the pubic joint in carrying the forces and resultant stresses from the upper body to lower limbs and particularly in different sporting activities.

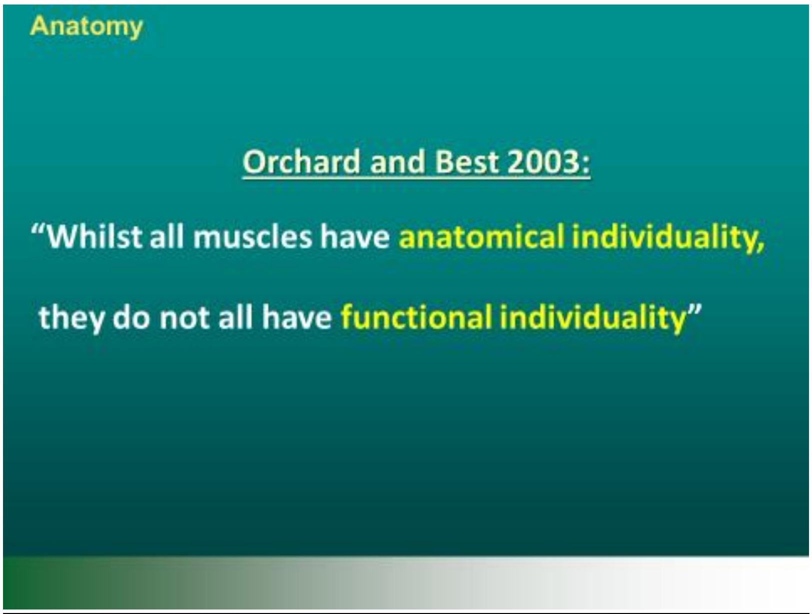
On request, Meyers provided “bullet points” for the Millson Handbook on Groin and Hips (2012) and outlined anatomic concepts essential in the management of these patients. The role of the pubic joint and associated areas was strongly highlighted as below:

- The pubic joint and its significant role in the management of groin pain.
- The aponeurotic plate (the fibrocartilage that surrounds both pubic symphyses)
- The centrally attaching muscles and soft tissues, e.g. rectus abdominis, pectineus, adductor longus and adductor brevis, versus the peripheral supportive muscles, e.g. rectus femoris, iliacus, psoas, sartorius
- Identification of core muscle functionality
- Inter-relationships between the hip and the pubic joint

Slide 20



Slide 21



Slide 20 clearly highlights the role of the hip and groin in relation to its combination of movement patterns and dysfunctions. Although groin pain from hip pathology is well recognized, lower anterior abdominal wall and anterior pelvis structures may also be interrelated sources of pain. Understanding the structural anatomy is essential to understanding the contribution made by the different structures. As shown on Slide 21, although muscles have anatomical individuality, they do not all have functional individuality and this provides further insight into how each structure relates to each other in movement.

Slide 22

Slide 23

High-risk activities such as soccer, ice hockey, rugby, basketball, athletics, hockey, cricket and others, place great strain on the fascial and musculo–skeletal structures that are fixed to various bony anatomical points in close proximity (Slides 22 and 23). These sports generate significant torsional stress at the transition zones between the abdomen and the pelvis which increases the risk of injury. This is particularly true for sports which involve rapid acceleration and deceleration, sudden changes in direction, kicking or twisting (Whittaker et al., 2015). If the clinician evaluates each individual sport and specific biomechanical demands of each position within the sport the resultant management would be possible. Evaluating the exact pelvic torsion for each sport or position therein would require very specific research and would be most useful. As there are no studies regarding this specificity, in my profession, I have endeavoured to either take part in the particular sport e.g. basketball for a better understanding of the requirements, or sat by the field for many hours analysing the different movement patterns and consequences thereof. This is time consuming, but most worthwhile in terms of specific management for prevention or rehabilitation. To date this is not done by the majority of clinicians, due to time restraints. I believe it should be mandatory for clinicians to spend more time in the practical area where the functional anatomy and biomechanical permutations are clearly demonstrated.

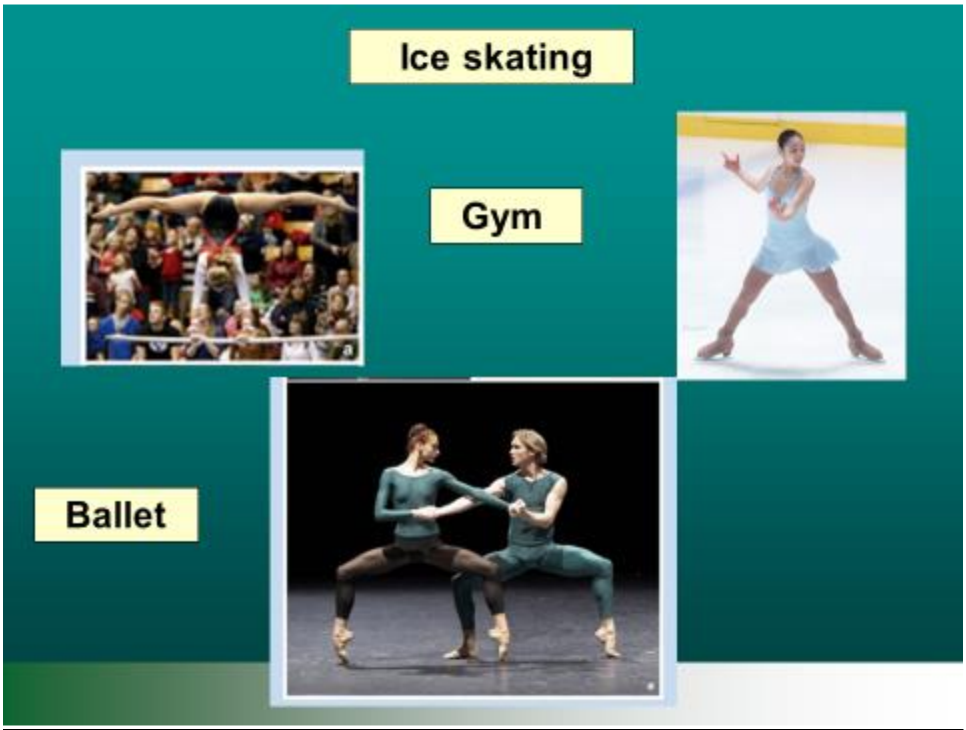
Slide 24

Slide 25

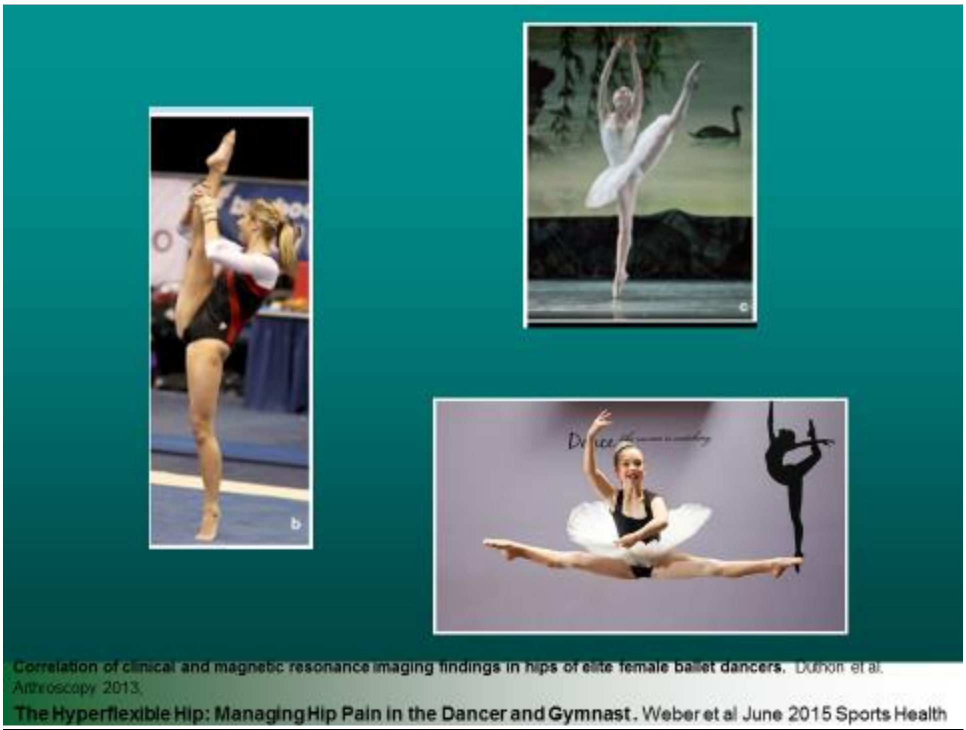
Slide 26

Slide 27

Slide 28



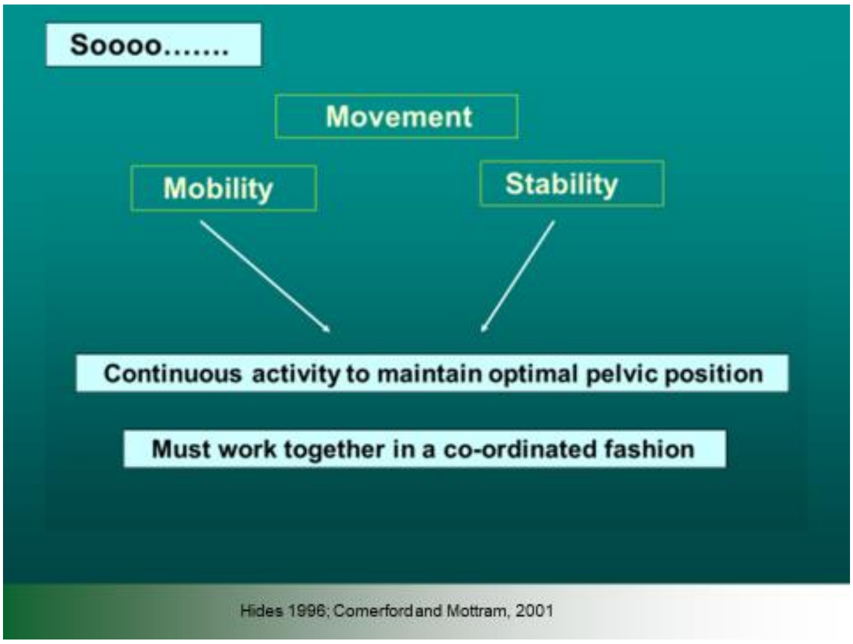
Slide 29



In my presentations, Slides 24 – 29 are discussed in depth e.g. as shown in Slide 25 the different demands on the groin and hip region in sports such as basketball, kick boxing, hurdling or weight lifting or Slide 27 and the biomechanical demands for cricket. These slides are explained clearly and the groin and hip area highlighted specifically. This is dependant on the attendees, the level of expertise that they have and the particular sports that they are managing. Historically, the exact details and nuances of each activity on the groin and hip area, has not been sufficiently covered in medical curriculae. This has been evident by the ongoing demands for my Presentations and the plethora of questions at each presentation.

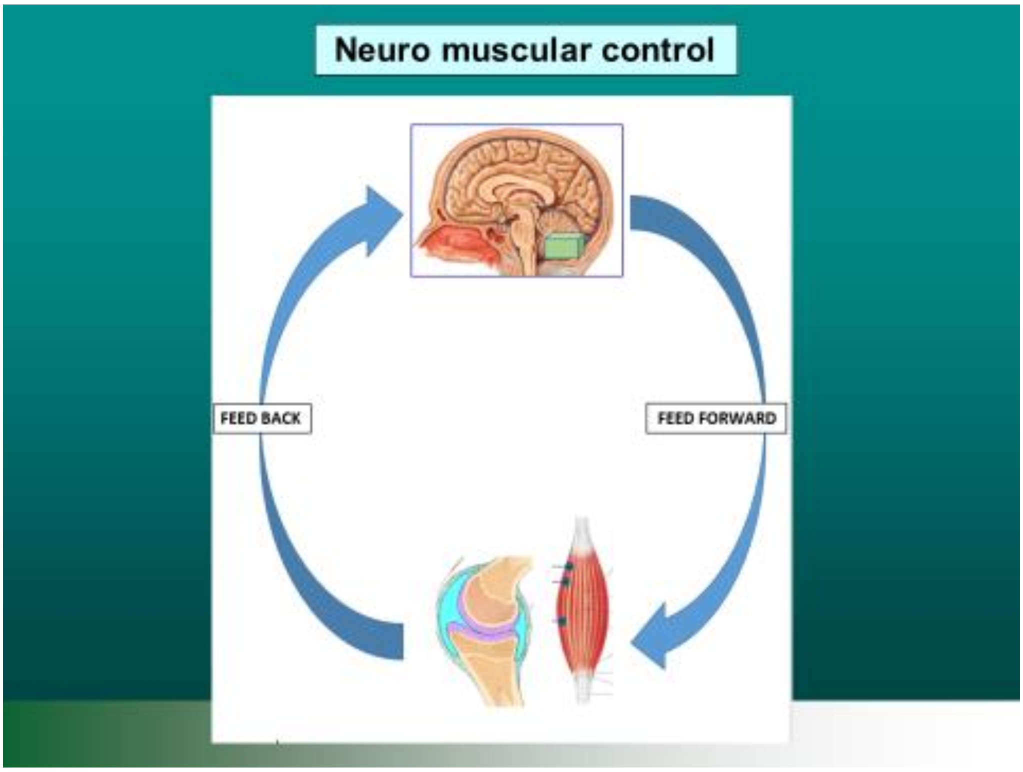
My aim is to focus the attendees on the groin and hip area and decipher the exact movement patterns for each sport, including ballet. I believe that we (including myself) have not realised the significance of the functionality of this area previously. Thus in order to prevent and rehabilitate groin and hip pathologies, the clinician needs to have a comprehensive knowledge of the sport, specific position adopted, the functional anatomy of relevant structures and specific biomechanics of the sport.

Slide 30



Slide 30 explains the role of mobility and stability in movement. Functional movement in any given sport can only be effective if the neuro-motor control is fully functional. To control movement, the nervous system must integrate multimodal sensory information and elicit the necessary signals to recruit muscles to carry out a goal. This pathway includes multisensory integration, signal processing, coordination, biomechanics, and cognition. Comerford and Mottram (2001) and Hides (1996), highlighted the importance of co-ordinated movement as it requires precise proprioceptive input from the periphery, processing and input from the central nervous system and involves timing of muscle recruitment as well as muscle contraction. Prevention and rehabilitation cannot be successful unless the neuro-motor factors are the basis of the management. This is taught at undergraduate level. However, from my experience, I realise that many clinicians underestimate the importance of neuro-motor control and how vital it is for athletes. I believe that this is also a crucial factor for enhancing performance in all sportsmen and women and have given many presentations / workshops Nationally and Internationally on this topic.

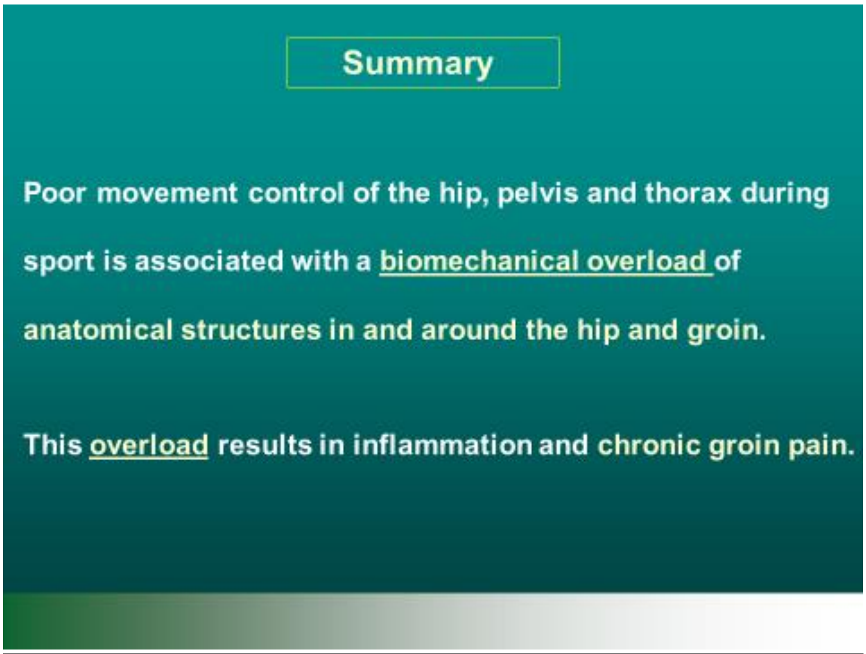
Slide 31



The feedback and feedforward components of the neuro-motor system is demonstrated in Slide 31. In my practice, I give most patients a copy of this diagram with a full explanation to give them a better understanding of the specific exercises that have been given to them and thus empower them to be compliant. This is a key point of my approach and is implemented from grass-roots to elite level in sports health care.

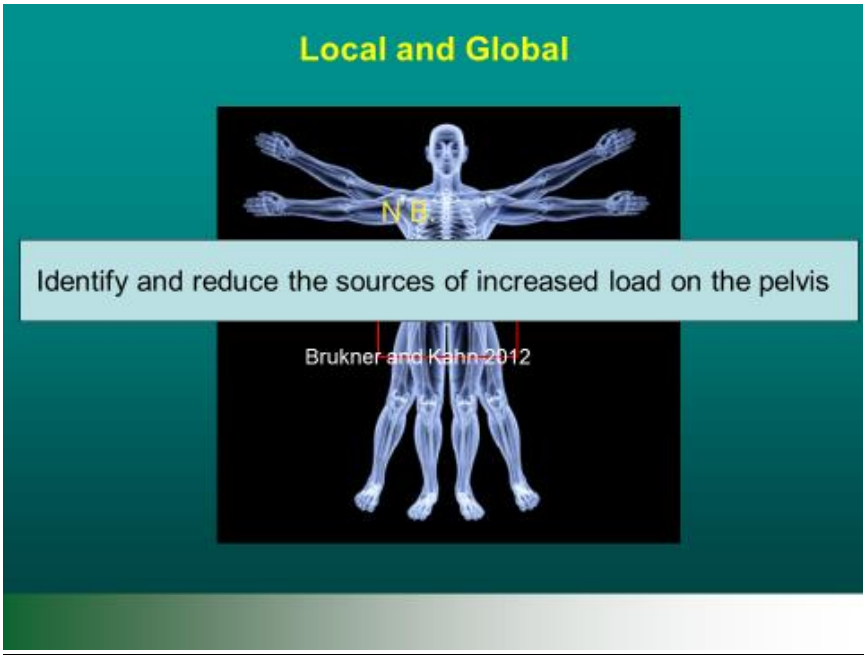
Neuro-motor control of the entire kinetic chain is an important factor in preventing groin and hip pathologies, whether it is post injury or for a preventative or a screening strategy (Comerford and Mottram, 2001; Hides and Stanton, 2014; Horobin and Thawley, 2015; Mischiati et al., 2015). Mendis and Hides (2016) highlighted how motor control training programs aimed at the lumbo-pelvic region also benefit the hip muscles. Their findings showed that players with current low back pain, who had the motor control training intervention mitigated sartorius muscle atrophy and increased gluteus medius muscle size. These findings are relevant in both the aetiology and management of athletes with groin or hip pain or potential pathologies by the parallel management of low back pain in elite football players.

Slide 32



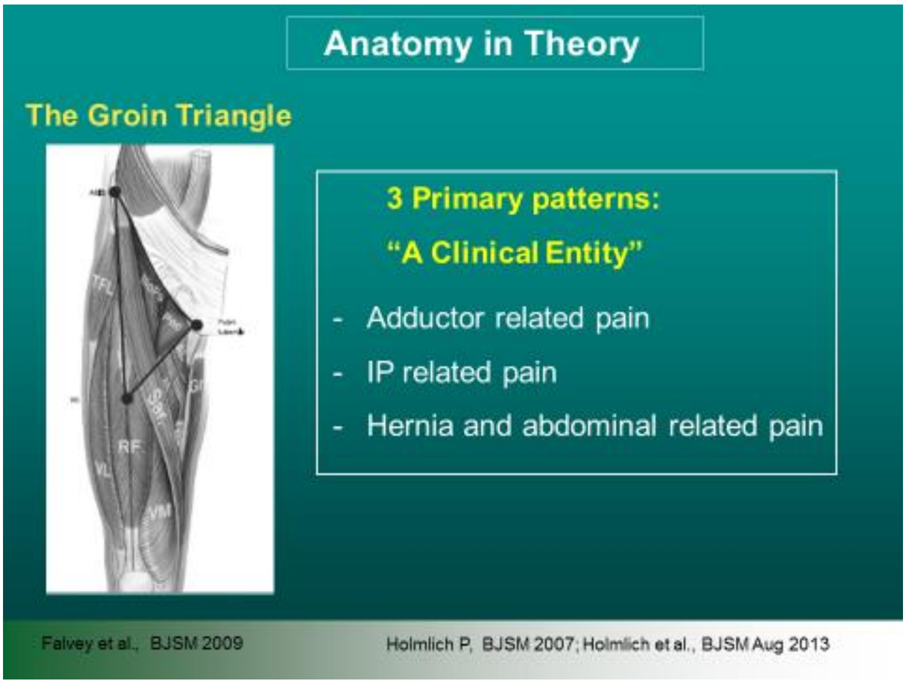
Movement control of the hip, pelvis and thorax during sports is associated with biomechanical overload of all these anatomical structures in and around the hip and groin region (Slide 32). As this overload may lead to pathology, providing optimal pre-habilitation of these regions would be a basic step in preventing overload in the first place (Chang et al., 2017). This management of overload is a crucial element of my prevention and treatment of athletes and will be explained in more detail in Chapter 10 – Risk Factors.

Slide 33

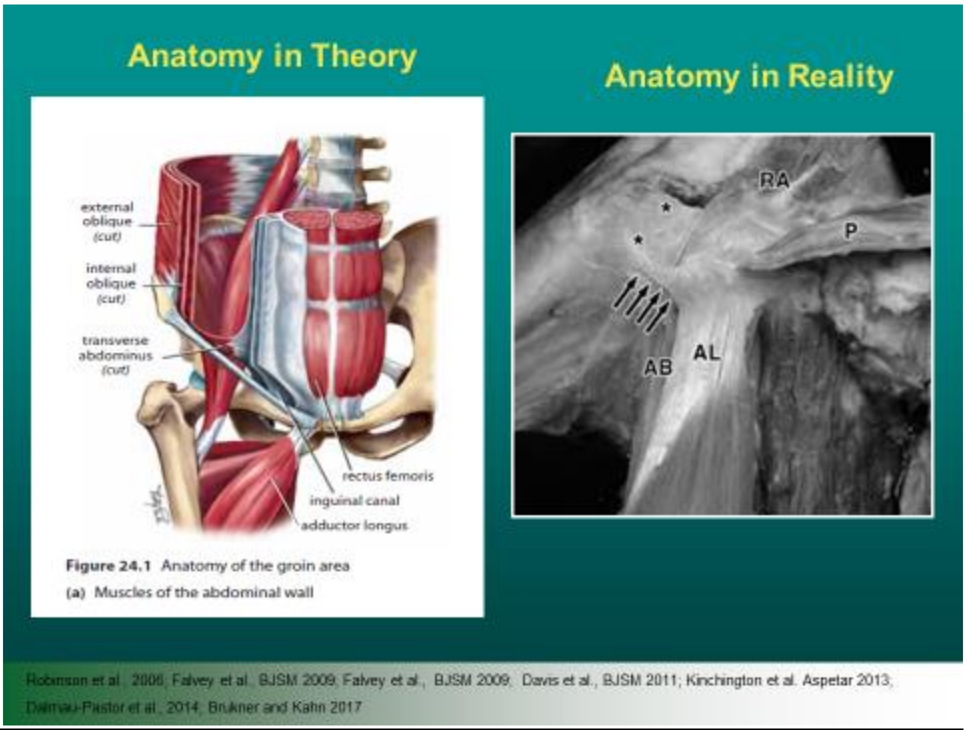


In "Clinical Sports Medicine" (Brukner and Kahn, 2017), the authors discuss the importance of understanding the functional anatomy and then identifying and reducing the sources of increased load on the pelvis (Slide 33). This has been a breakthrough in looking at the anatomy in a functional manner and has been my goal for many years. I believe that this education should be mandatory in the education of sports clinicians, as this has not always highlighted. Clinicians are taught specific anatomical structures and underestimate the crucial point of functional anatomy. This is a most important part of my presentations, no matter to whom I am presenting. The clinician requires good anatomical biomechanical knowledge and thus the ability to assess the athlete for any malfunction. In many instances in my profession, I have not been able to pinpoint a specific diagnosis when confronted with an athlete with hip or groin pain. The criteria for me is in the assessment of possible increased load and/or malfunction. This may be lengthy in terms of time, but I have definitely found it constructive to identify any impairments and correcting them without the specific diagnosis. The resultant effect is prevention of a hip or groin problem or full recovery from an injury. Whilst with the Super 14 Rugby team I did a musculo-skeletal pre-season screening on each player, which included one specifically for the pelvic, groin and hip area. The PNF pattern which I utilised was not previously used in this context. I started using it in musculo-skeletal assessment and realised the excellent outcome in identifying groin and hip weaknesses. This was even shared with some of my medical colleagues in Premier League, as it is most pertinent to the functionality of football kicking. This was followed by specific static and functional exercises where required. Although this is anecdotal, I believe that this may have prevented groin and hip injuries to a degree.

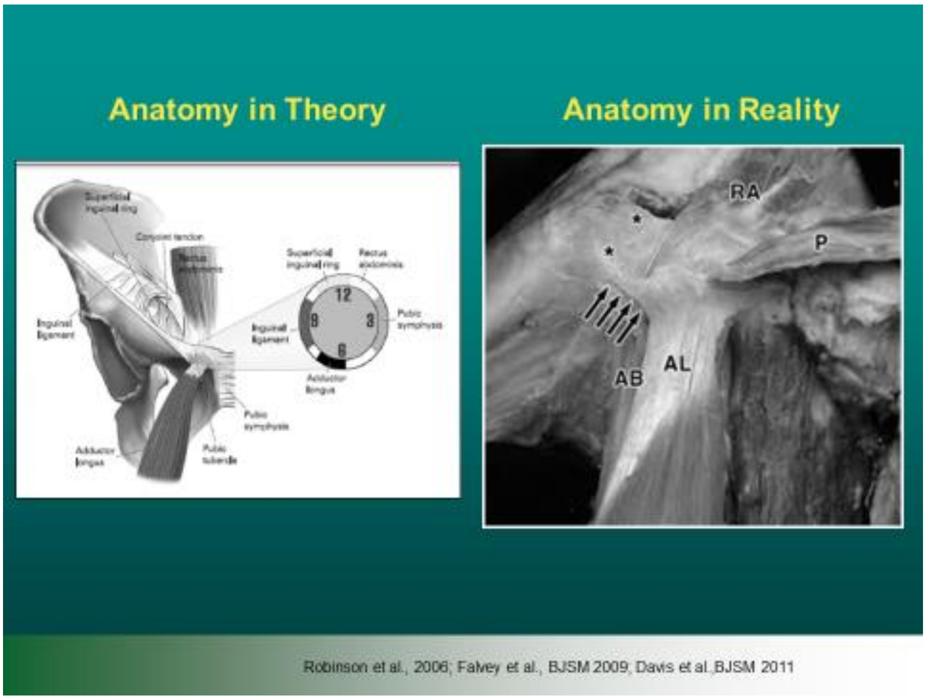
Slide 34



Slide 35



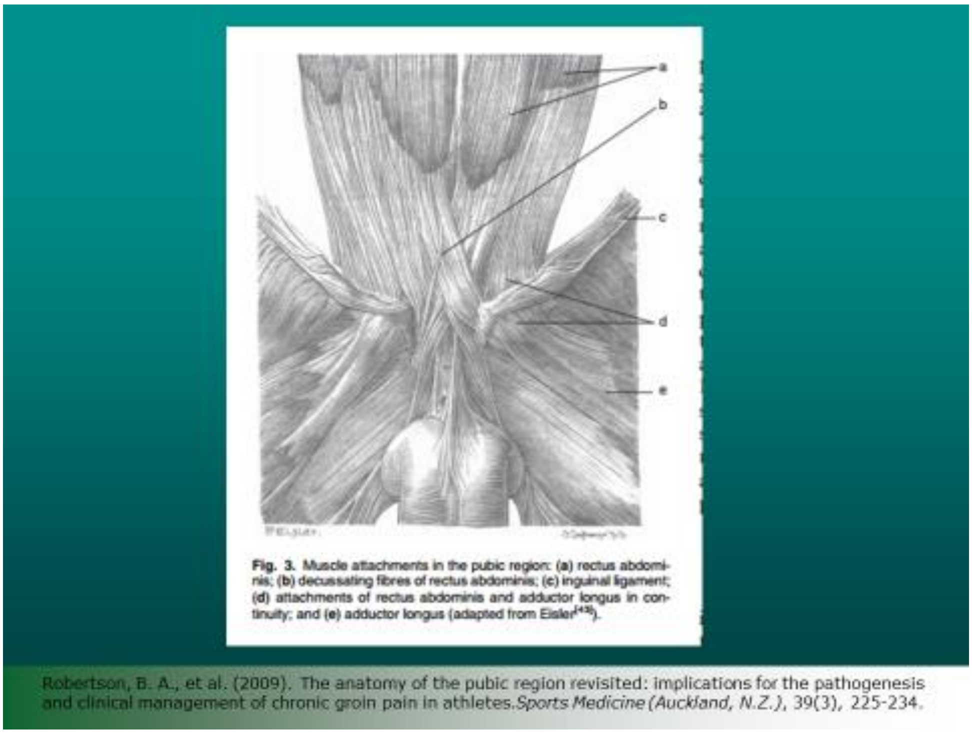
Slide 36



As clearly shown in Slides 34 - 36, one of my primary objectives when giving presentations over the past years, has been to demonstrate the importance of structural and functional anatomy of this area and to highlight the disparity between anatomy in theory and anatomy in reality. Falvey et al. (2009) demonstrated a model which is relevant for interpretation of anatomical structures (Slide 34). They proposed an educational model based on patho-anatomical concepts which is a major part of my presentations. Anatomical reference points were selected to form a triangle namely the 3G approach (groin, gluteal and greater trochanter triangles), permitting the clinician to move throughout the region and consider pathologies appropriately. On Slide 35 and 36, one can see the difference of learning the precise structural anatomy from many text books and then observing the anatomy in patients during surgery or even cadavers to understand the multiple attachments and consequential complexity of the interaction of the muscles, which is often not represented in a 2-dimensional drawing.

In a presentation I gave to surgeons at Gilmore’s practice in London (2013), I highlighted the importance of functional anatomy and even explained why it is important for there to be less surgery and more understanding of this functionality. I had expected a negative response to my frank presentation. However, the surgeons were very open to discussion thereafter and even asked me for some of my slides after the presentation. This frank discussion is not common practice from physio to specialist. However, I felt the need to be transparent, as I have been observing the over-emphasis for surgery in the Premier League and other elite sport.

<u>Slide 37</u>



Slide 37 shows this interaction and the intimate relationship between the adductor longus, rectus abdominus and symphyseal cartilage, disk and capsular tissues, (Robertson et al., 2009 and Robinson et al., 2007). It is thus surprising that management has not previously taken sufficient cognisance of this factor and that one cannot manage the hip and groin area without including all these anatomical structures and their functionality in all movements, as well as the entire kinetic chain. I personally, have only come to realise in the past few years of this relevance, as have my colleagues (all levels of medical personnel), who admit to this lack of acknowledgement previously during discussions at my presentations.

<u>Conclusion – General Anatomy</u>

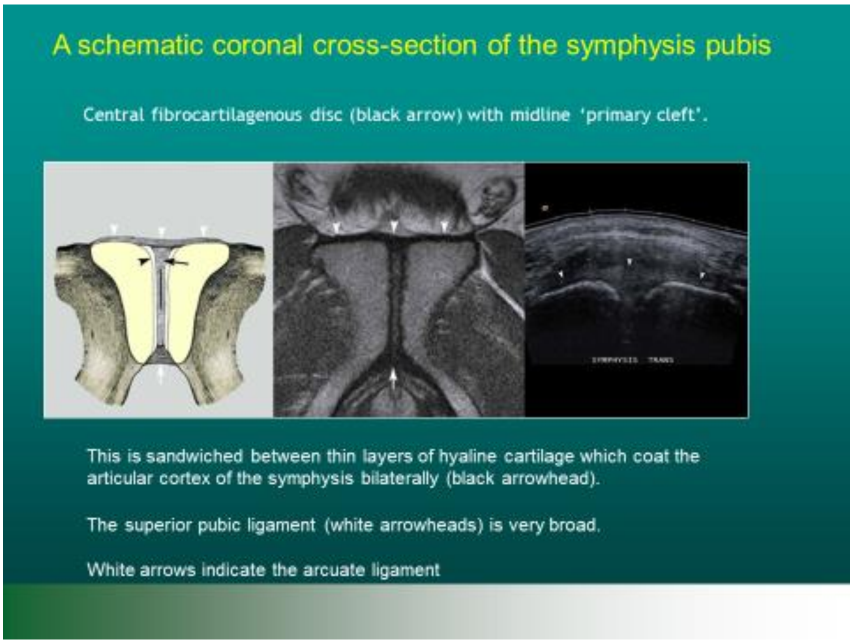
The key factor when rehabilitating or preventing groin and hip pathologies is for clinicians to acknowledge that while all muscles have anatomical individuality they do not have functional individuality. An in-depth understanding of the anatomy, be-it structural or functional, is the cornerstone of management. Further, individual movements in specific sports should be analysed in respect of musculo-skeletal and neuro motor movement. Thus acknowledging these factors and following correct procedures should enable the prevention and rehabilitation of groin and hip problems.

3b. Specific Anatomical Areas

3b i   Pubic Joint

As has been briefly discussed, the concept of the pubic joint is the key to understanding the various injuries. When thinking prevention or management for groin and hip injuries, the maintenance of balance around the pubic joint is vital (Meyers et al., 2007).

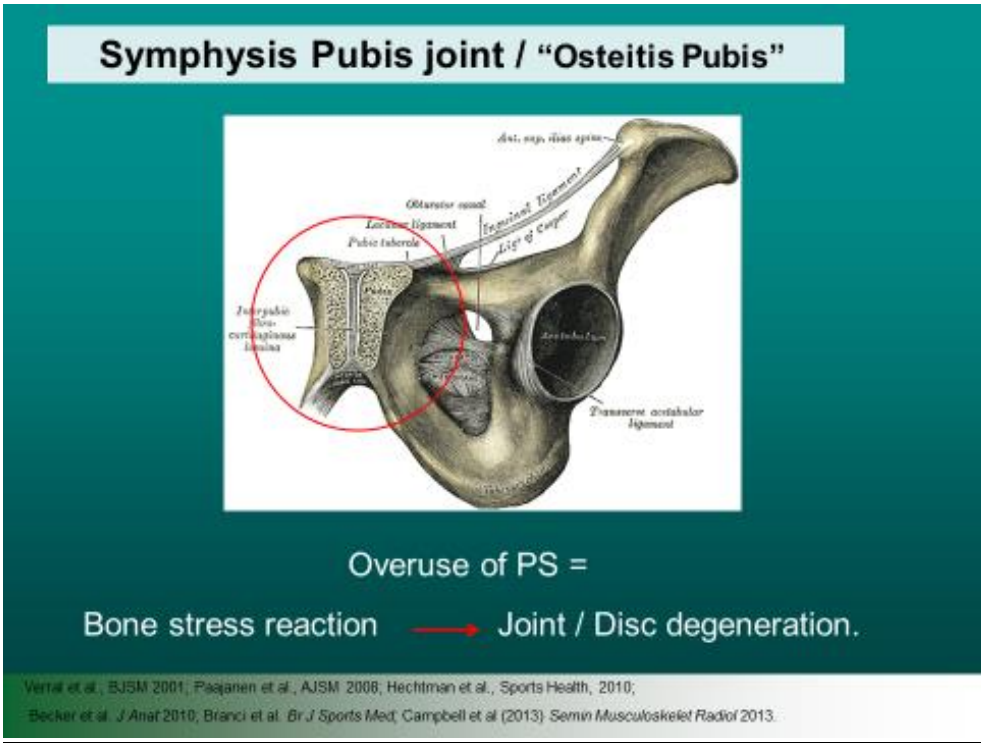
Slide 38



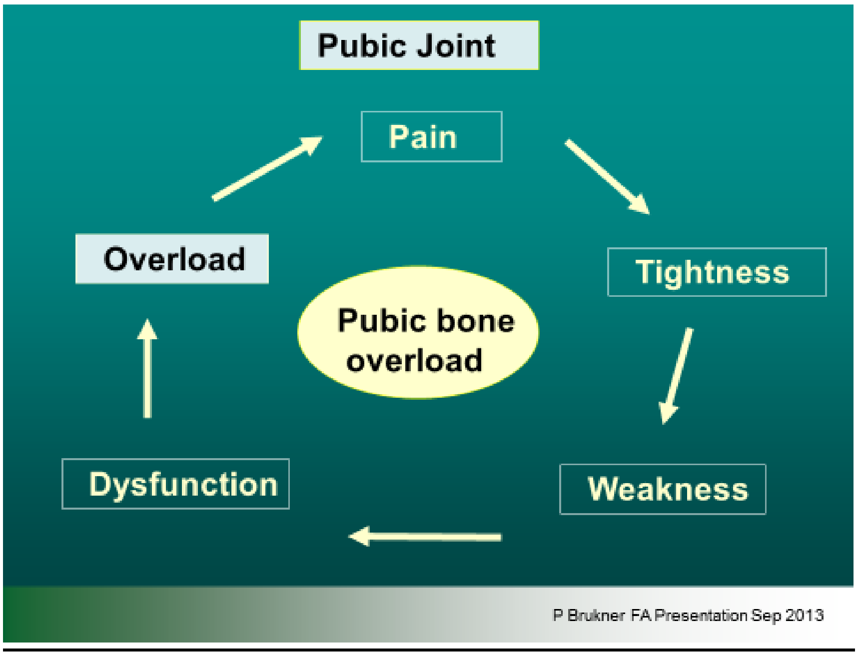
The anatomy of the pubic symphysis and its role with regard to the entire kinetic chain, has not been fully analysed in the past. The pubic symphysis consists of a central fibro-cartilagenous disc which is sandwiched between thin layers of hyaline cartilage which coat the articular cortex of the symphysis bilaterally. The fibro-cartilaginous disk is reinforced by a series of ligaments including the superior pubic ligament and the inferior pubic ligament, which provide the most structural stability (Slide 38). The strong and thicker superior ligament is reinforced by the tendons of the rectus abdominis muscle, the abdominal external oblique muscle, the gracilis muscle, and by muscles of the hip. This allows the transfer of weight of the upright trunk from the sacrum to the hips. The attachments and the intimate relationship of adductor longus, rectus abdominis and the symphyseal cartilage, disc and capsular tissues at and around the symphysis pubis were observed in a cadaver and MRI studies (Robinson et al. 2007).

Understanding the anatomical attachments surrounding the pubic symphysis, highlights the implications for instability around this joint. Instability of the pubic symphysis may cause traction and shearing force where the muscles insert into the pubic symphysis and thus may be responsible for chronic stresses and imbalance. This may lead to the onset of a bone, muscle-tendon or inguinal groin pain. This instability may either have a functional or structural mechanism. Altered biomechanics or muscle imbalance will lead to functional imbalance of the pubic symphysis (Robertson et al., 2009). It is clear that the pubic symphysis can have a far-reaching effect on hip and groin pathology and should always be considered in a clinical examination of a painful athlete. In my practice, I have found that by correcting any malfunction and muscle imbalances around the pubic symphysis, the chances have been high for correcting any abnormalities and thus preventing or rehabilitating many hip and groin problems. This analysis of the functional anatomy has not always been common practice amongst clinicians and it has been important that going forward I highlight this factor in my presentations

<u>Slide 39</u>

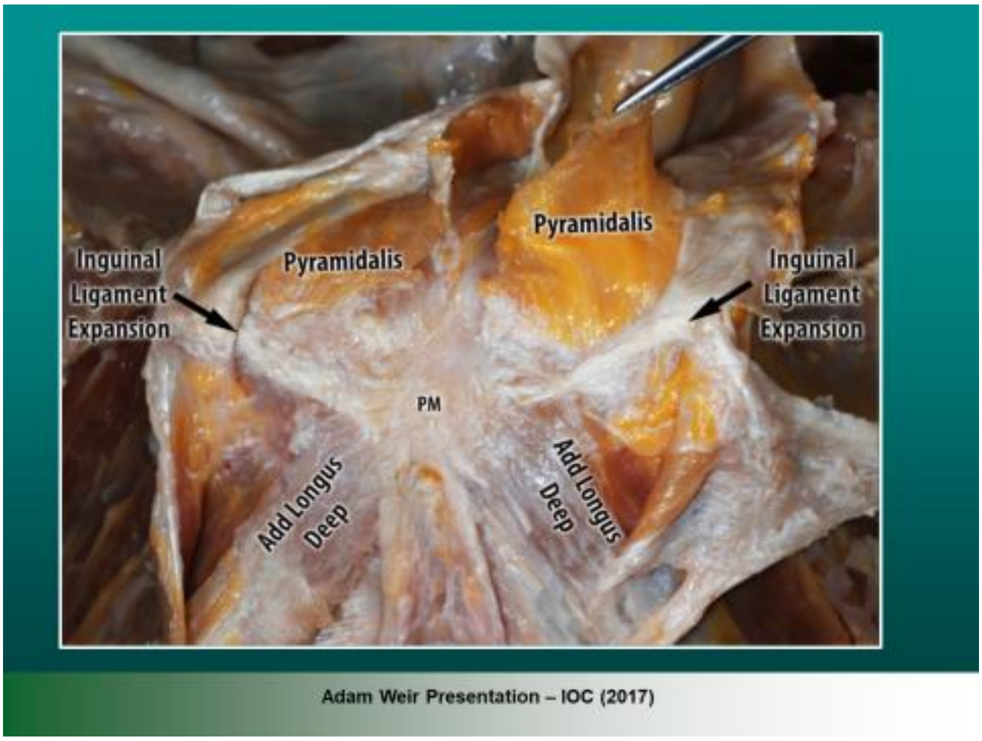


Slide 40

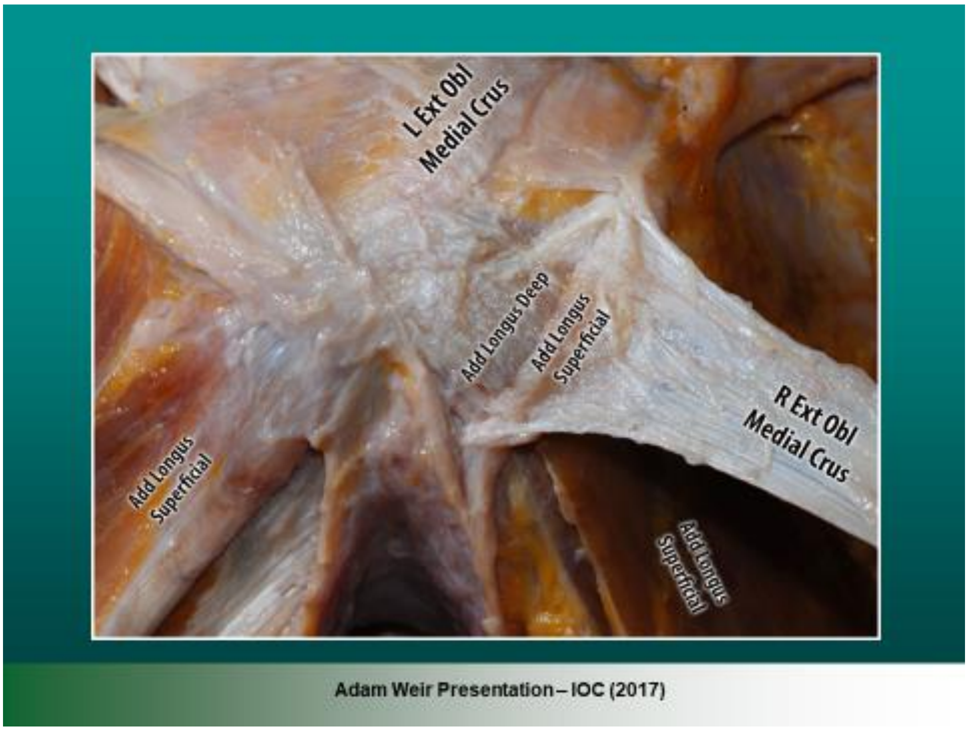


Slides 39 and 40 explains the stress on the pubic symphysis joint and as has been mentioned previously, the term "osteitis pubis" has been used for many years and apart from a few studies, it is only recently that the term pubic bone stress has been the accepted terminology. This is due to the observed bone marrow oedema being described as a natural phenomenon and a consequence of pelvic overload in sport (Moore, 2012). To this day, I still believe that a pubic bone stress time line would be of benefit to clinicians. This may give clinicians an idea as to the amount of load that is present and the consequential management of unloading the pubic joint appropriately. There was some debate at the Groin and Hip Conference in 2014 (Aspetar - First World Conference) and 2016 (Football Medical Association Conference), when the expert panels were asked the relevance of pubic bone stress with regards to a time continuum and the possibility of an asymptomatic pubic bone stress becoming symptomatic. Future research is needed to provide insight into the relevance of the increased uptake of pubic bone stress and a time line to analyse the continuum of the increased uptake and thus possible prevention of any hip and groin pathology.

Slide 41



Slide 42



Regarding functional anatomy, one of the biggest lessons to be learnt from the anatomy of the hip and groin is interconnectedness of the tendons around the pubic joint and thus the resultant overload of the joint and other muscles, particularly if the muscles are weak (Weir, International

Olympic Committee Advanced Team Physician Course, Turkey 2017) (Slides 41 and 42). This understanding would lead to more in-depth evaluation of muscle imbalance and appropriate strengthening, not only of the adductor muscles, but also the abdominal muscles and other related muscles which play a major role in all functional movements, particularly in sports. "Core stability" has been the focus for everyone over the past years without realising the implications of the interconnectedness around the pubic joint and load management from the upper trunk to the lower trunk and lower limbs. This requires consideration for prevention of groin and hip problems.

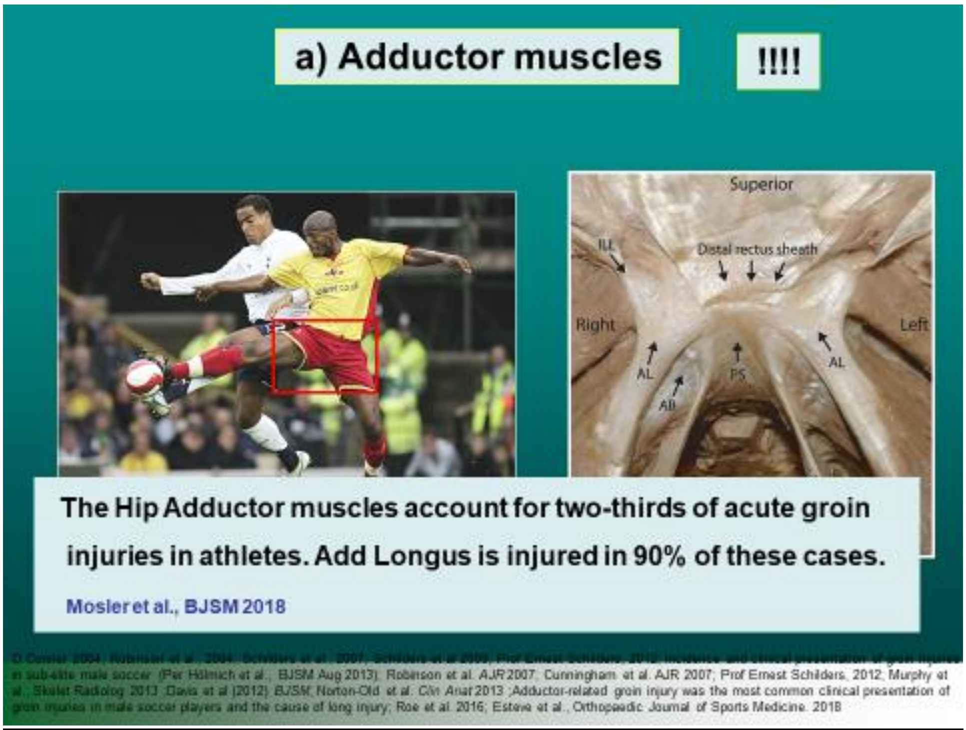
At the Football Medical Association Conference (May, 2016), Holmich stated in his presentation that one must be careful interpreting these anatomical structures and the so-called "direct" connection between muscles. He said that there is a difference between the bony attachment of the various tendons and the fascial connection which undoubtedly work together as structures, but this is a biomechanical factor and not necessarily a direct connection. He believed that one should be very careful not to be dogmatic regarding the "crossover effect" of the tendons joining up over the pubic area. This is currently an ongoing point of discussion. However, from my experience, this "crossover effect" i.e. realising the implications of all the muscles involved around the pubic area and the crossover transference of load from one side of the upper body to the opposite side of the lower limbs via this pubic area is crucial. Although complex, it should be a guide for providing assessment and management of groin and hip pain. In my practice, even if I have not been able to give a definitive diagnosis for a patient, I have fully rehabilitated them by working on all the relevant structures associated with the pubic joint and not just concentrated on the groin or hip specifically.

Conclusion – Pubic Joint

From the rehabilitation perspective for the implementation of a successful management programme, I suggest an in-depth understanding of all the muscle/ tendon/ fascial attachments to the pubic area and the consequential implications for functional movement.

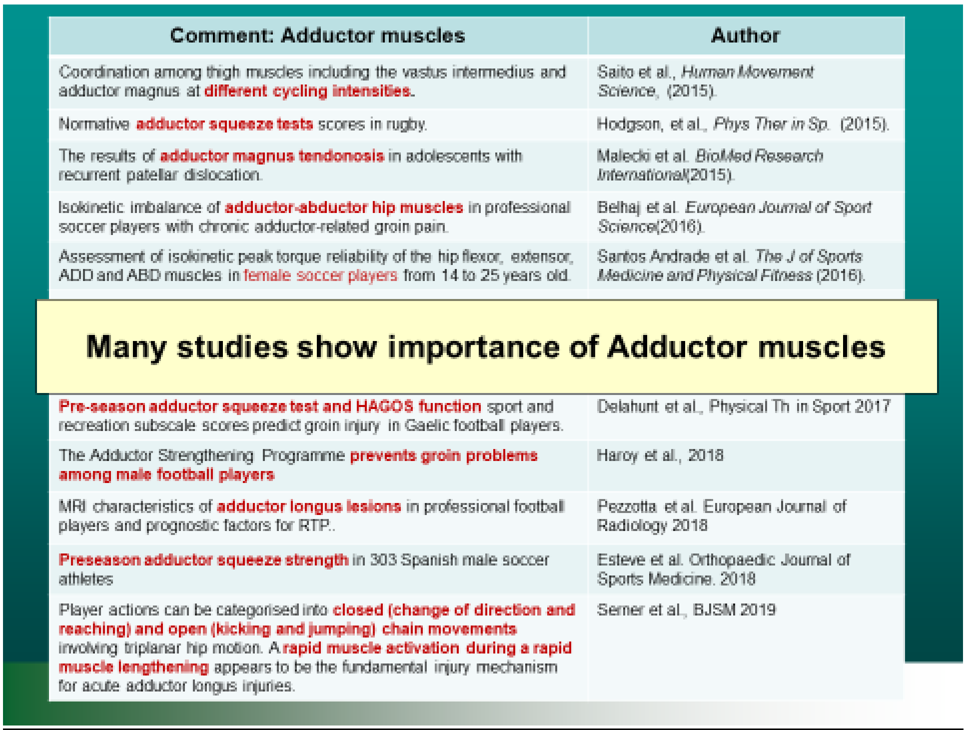
3b ii. Adductor Muscles

Slide 43



It has been shown that adductor muscle injuries occur in 13-70% of groin injuries (Ekstrand et al., 2011; Mosler et al., 2018; Schilders et al., 2007; Schilders et al., 2013; Serner et al., 2014) (Slide 43). Adductor muscle strains can result in missed playing time for athletes in many sports. This appears to be the case in most of the sports that require a lot of turning, kicking, twisting, acceleration and deceleration, or high intensity hip abduction. In sports such as ice hockey and soccer where there is strong eccentric contraction required of the adductor muscles, there is a high incidence of adductor strains (Coughlan et al., 2014; Cunningham et al., 2007; Delmore et al., 2014; Grote et al., 2004; Holmich et al., 2013; Hrysomallis, 2009; Jensen et al., 2014; Schilders et al., 2007; Thorborg et al., 2011). It is interesting to note that as far back as 1997, Jarvinen et al. described groin pain as an “Adductor Syndrome”. Despite the identification of risk factors and strengthening intervention for ice hockey players, adductor strains continue to occur (Nicholas and Tyler, 2002). In my career, whilst dealing with elite sport and in particular, football, I have learnt that although the adductor strengthening programme is now being undertaken, the adductor muscles are not always strengthened functionally e.g. holding the leg in a hip flexion, adduction and external rotation (as in the kicking action). Since working with the Stormers Rugby team and identifying the weakness of the adductor muscles in the majority of the players, I have continued to grow my knowledge by analysing all sports (and positions therein) and noting the different function of the adductor muscles in each instance.

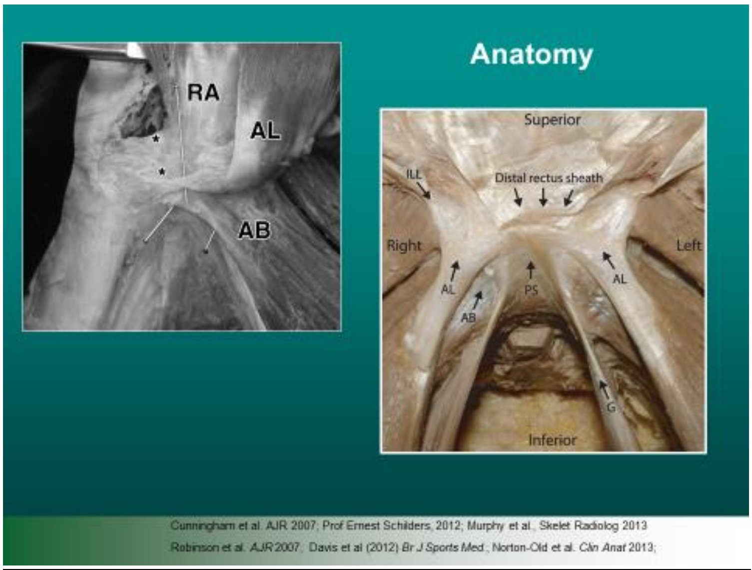
Slide 44



Comment: Adductor muscles	Author
Coordination among thigh muscles including the vastus intermedius and adductor magnus at **different cycling intensities.**	Saito et al., *Human Movement Science*, (2015).
Normative **adductor squeeze tests** scores in rugby.	Hodgson, et al., *Phys Ther in Sp.* (2015).
The results of **adductor magnus tendonosis** in adolescents with recurrent patellar dislocation.	Malecki et al. *BioMed Research International*(2015).
Isokinetic imbalance of **adductor-abductor hip muscles** in professional soccer players with chronic adductor-related groin pain.	Belhaj et al. *European Journal of Sport Science*(2016).
Assessment of isokinetic peak torque reliability of the hip flexor, extensor, ADD and ABD muscles in female soccer players from 14 to 25 years old.	Santos Andrade et al. *The J of Sports Medicine and Physical Fitness* (2016).
Many studies show importance of Adductor muscles	
Pre-season adductor squeeze test and HAGOS function sport and recreation subscale scores predict groin injury in Gaelic football players.	Delahunt et al., Physical Th in Sport 2017
The Adductor Strengthening Programme **prevents groin problems among male football players**	Haroy et al., 2018
MRI characteristics of **adductor longus lesions** in professional football players and prognostic factors for RTP..	Pezzotta et al. European Journal of Radiology 2018
Preseason adductor squeeze strength in 303 Spanish male soccer athletes	Esteve et al. Orthopaedic Journal of Sports Medicine. 2018
Player actions can be categorised into **closed (change of direction and reaching) and open (kicking and jumping) chain movements** involving triplanar hip motion. A **rapid muscle activation during a rapid muscle lengthening** appears to be the fundamental injury mechanism for acute adductor longus injuries.	Serner et al., BJSM 2019

A small percentage of the multitude of adductor studies is demonstrated on Slide 44. There are an increasing number of studies to show the importance of the adductor muscles in relation to the strength and balance required in most sports, as well as the fact that adductor longus is the most frequently injured muscle in groin and hip pathologies (Holmich et al., 2014 and Serner et al., 2015). In a screening evaluation, as well as for rehabilitation, strength and balance can be assessed appropriately as a prevention strategy (as discussed in Chapter 5 – Assessment). Whilst the importance of the adductor muscles is implied in the scientific literature, it does not always seem to be applied by the clinical community, as can be seen by the continued high numbers of hip and groin injuries (Cianci et al., 2019; Pezzotta et al., 2018; Thorborg et al., 2018). Thus my presentations always strongly include the importance of a specific adductor strengthening programme for each athlete related to their specific requirements. Since 2000, working with the Stormers Rugby team and noting (anecdotedly) how our groin/hip injuries (as well as the hamstring strains) receded, I have been undertaking an adductor strengthening programme with positive outcomes and sharing this protocol with my colleagues.

Slide 45

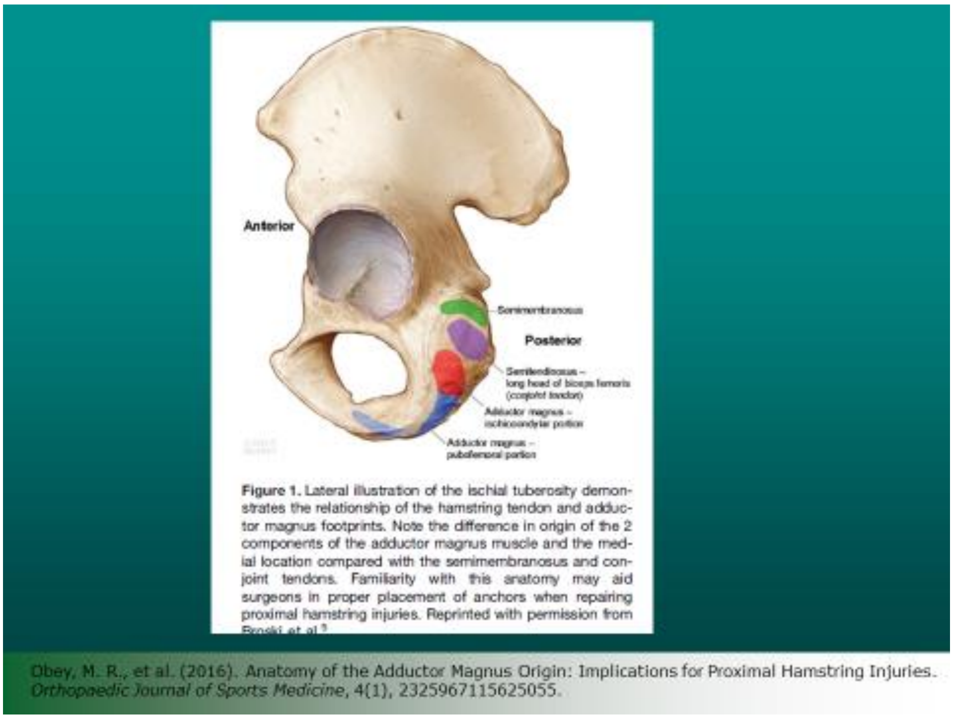


The proximal anatomy of adductor longus, adductor brevis and gracilis is complex (Slide 45). The arrangement and fusion of these muscles, their fibro-cartilaginous entheses and differences in vascularity of their proximal tendons may be important anatomical considerations in the pathogenesis and pattern of adductor-related groin pain and consequently the management thereof (Davis et al., 2012). I believe that specific and relevant strengthening and an awareness of maximal strength of all these muscles and the consequential correct movement may prevent groin and hip pathologies from developing in the first place. Fortunately this is now being put into practice as a normal procedure, which, from my practice and observation, was not the case 10 years ago

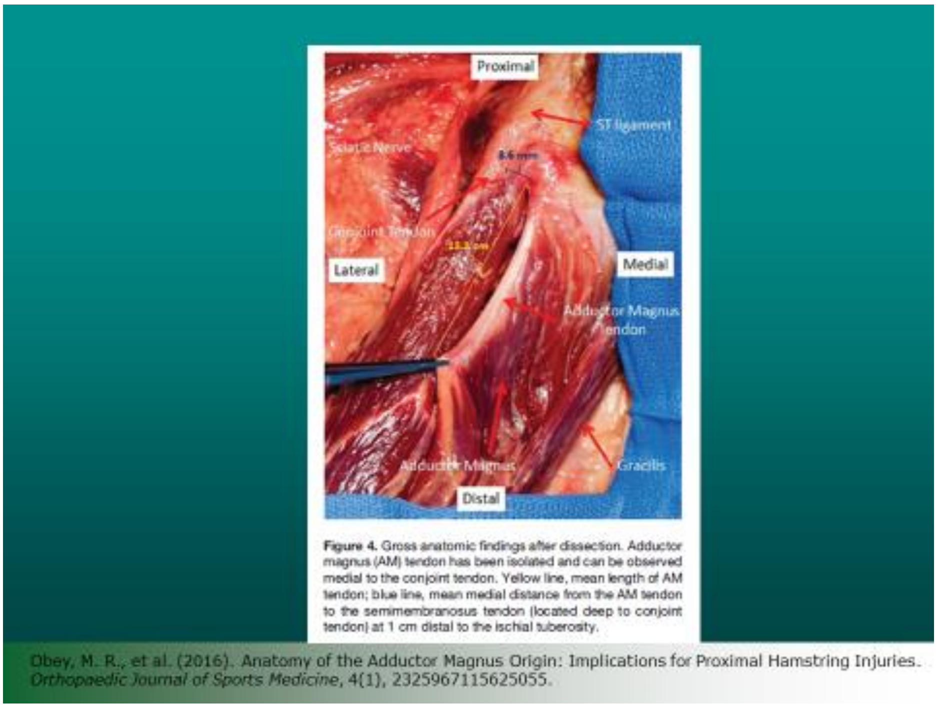
Cunningham et al. (2007) stated that in soccer player with "athletic pubalgia," adductor dysfunction was a more frequent MRI finding than osteitis pubis / pubic joint dysfunction. Both entities are mechanically related and they frequently co-exist. They hypothesised that adductor dysfunction might precede the development of the so-called osteitis pubis. Thus the fact that there may be more than one pathology leading to the "groin pain", re-enforces my management of looking at the entire kinetic chain and specifically analysing the load through the pubic area from above and below the groin.

Serner and Jomah (2014) re-affirmed that the most acute injuries are adductor-related and their preliminary results support the belief that the adductor longus muscle is most frequently injured, with kicking being the most commonly reported injury mechanism. They developed a useful classification system for adductor muscle injuries (Grade 1 to Grade 4) for acute groin injuries. As will be discussed in the rehabilitation chapter, specific exercises to strengthen the muscles involved with kicking action should be mandatory for prevention of adductor muscle injuries. This has not been the case from my observation over the years. Fortunately this new specific knowledge is slowly filling the gap and the clinician's are experiencing a more fruitful rehabilitation outcome.

Slide 46



Slide 47



When starting my work with the Stormers Super 14 Rugby Team (2000 – 2006) as physiotherapist, I constructed a specific pre-screening proprioceptive neuromuscular facilitation assessment and consequential strengthening programme which targeted the adductor muscles (Chapter 5b iii). Previously, the players had sustained many hamstring injuries. It was most interesting at the time to observe that apart from the strengthening of the adductor muscles, the hamstring injuries were "incidentally" reduced considerably. Thus, it was most intriguing many years later to analyse the study of Obey et al. (2016) whereby previously, the mostly ignored factor of the anatomy of the adductor magnus muscle origin and the implications for proximal hamstring injuries were detailed. They stipulate that detailed knowledge of the adductor magnus tendon anatomy, footprint anatomy, and its relationship to the hamstring muscle complex was important in managing hamstring injuries (Slides 46 and 47). This may also indicate that the hamstring is another muscle that must be considered in the assessment and management of hip and groin injuries. This study provides support for the prevention strategy implemented with the Stormers Rugby in reducing hamstring injuries. Thus this proprioceptive neuromuscular facilitation protocol (which will be discussed in Chapter 5 – Tests), may be of benefit for groin and hip problems and particularly, as a prevention strategy. Further, the critical key is to recognise the associated muscles and the entire kinetic chain. As important as they are, one should not manage the adductor muscles in isolation.

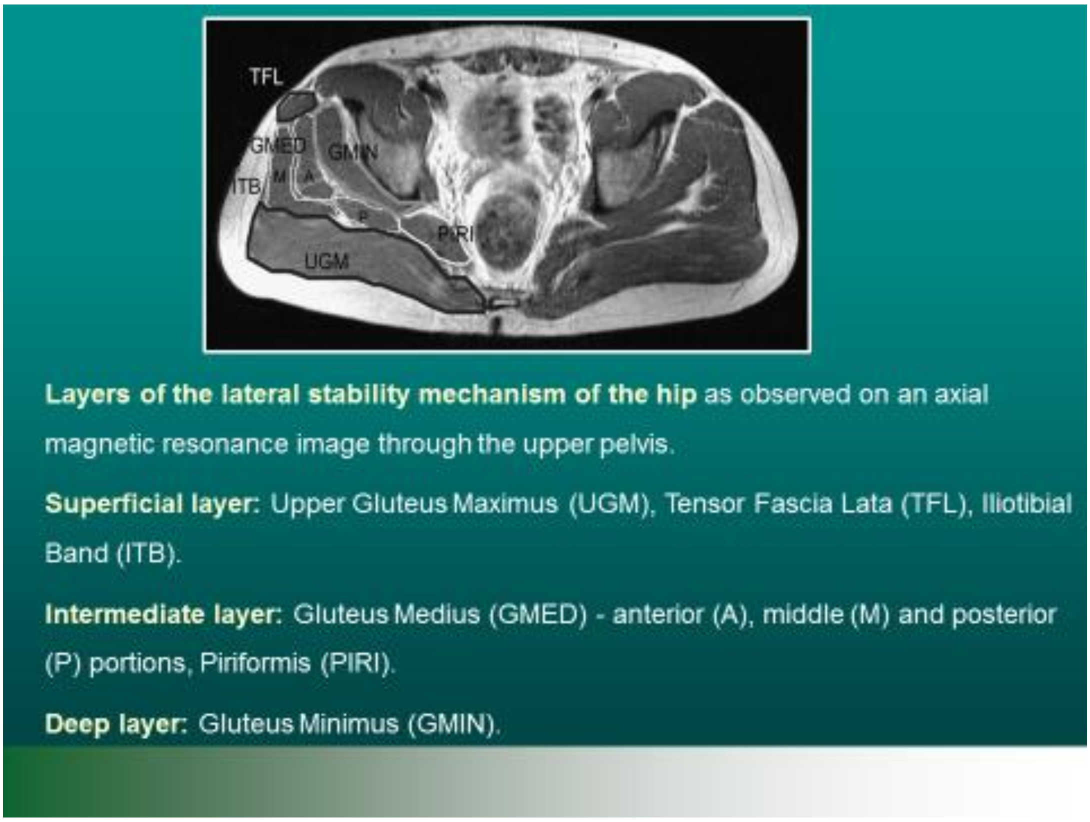
At the Manchester Consensus Conference on groin and hips (2012), important strategies regarding initial treatment and rehabilitation programme for inguinal disruption were mentioned. However, the adductor muscles were not specified. At the Consensus agreement in Doha on terminology and definitions in groin pain in athletes (2014), adductor-related groin pain was one of the defined clinical entities. Thus there has definitely been some progress over the past years and clinicians may realise that strong and functional adductor muscles are a most important factor for prevention and rehabilitation of most athletes with potential or current groin pain.

Conclusion: Adductor Muscles

The problem of weak adductor muscles and its link to groin and hip pain is undisputed in practice, as well as in the mentioned studies. One needs to differentiate between the orthodox understanding of anatomical anatomy and the understanding of inter-relationships of different anatomical structure i.e. functional anatomy. This could be an opportunity for future research.
I suggest the clinician should analyse the scientific literature, as well as having an in-depth understanding of all the basic structural and functional anatomy. Further, the examination of all of the functional movements of the entire kinetic chain and identifying the cause for this weakness and any mal-adaptations may allow optimal management. I have found this to be most useful in my practice over the years. These findings have implications for assessment, rehabilitation, return to play criteria, as well as for a prevention approach. This will be highlighted in the relevant chapters (Chapters 8, 9, 11).

3b iii. Gluteal muscles

Slide 48

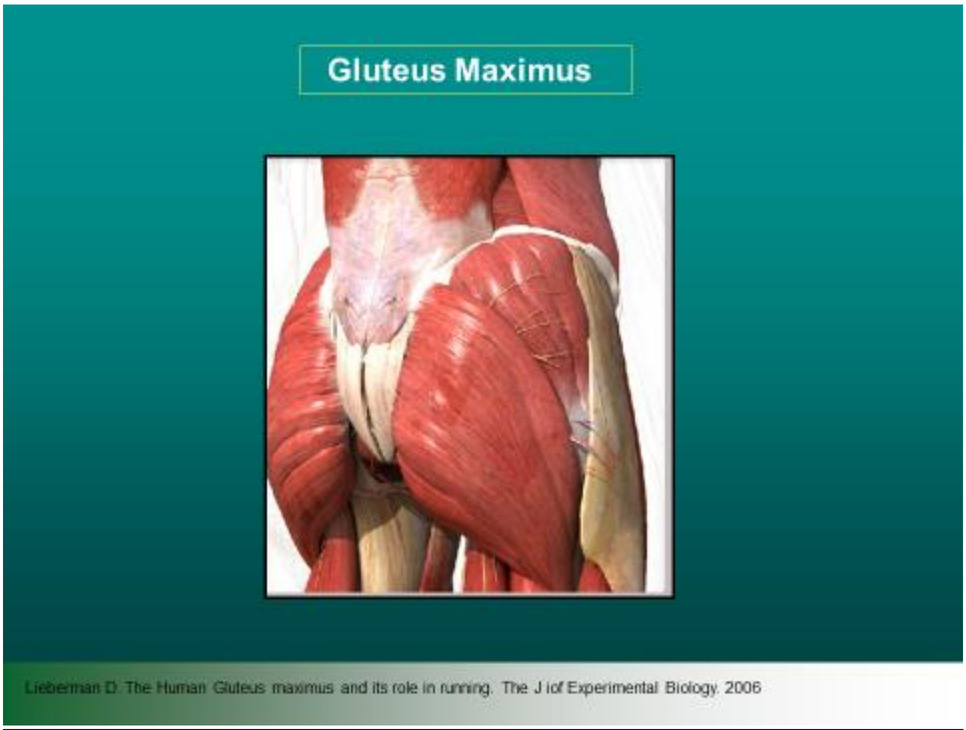


Slide 48 gives clear illustration of the gluteal muscles which consist of Gluteus Maximus, Gluteus Medius and Gluteus Minimus, each having varied functions and working closely with the Tensor Fascia Latae. They are considered key muscles for maintaining pelvic stability, hip stability, upright posture and locomotion (Semciw et al., 2016).

Femoro-pelvic alignment is the end result of the complex interactions between all members of the abductor muscle synergy (Grimaldi, 2011). Grimaldi demonstrates the close association between hip abductor function and segmental alignment of the femur, pelvis and trunk and explained how clinical assessment of the lateral stability mechanism of the hip and pelvis identified abnormalities in postural habits and movement patterns that may reflect dysfunction of the hip abductor muscles. She also described the importance of the different layers with resultant different functionality. I personally do not think that in the past I took sufficient cognisance of the influence of the gluteal muscles on the entire kinetic chain. However, the acknowledgement and analysis of all the evidence and practical analysis as a result of undertaking this thesis, has most definitely improved my management of all my athletes. That is not only for groin and hip problems, but many other injuries or potential injuries (such as hamstring strain, ACL strain etc) may be prevented by the recognition and consequential management of these important muscles. This management of the gluteal muscles has been a major factor in my development of prevention and rehabilitation of groin and hip problems over these past 5 years and most importantly, when sharing this valuable information with clinicians.

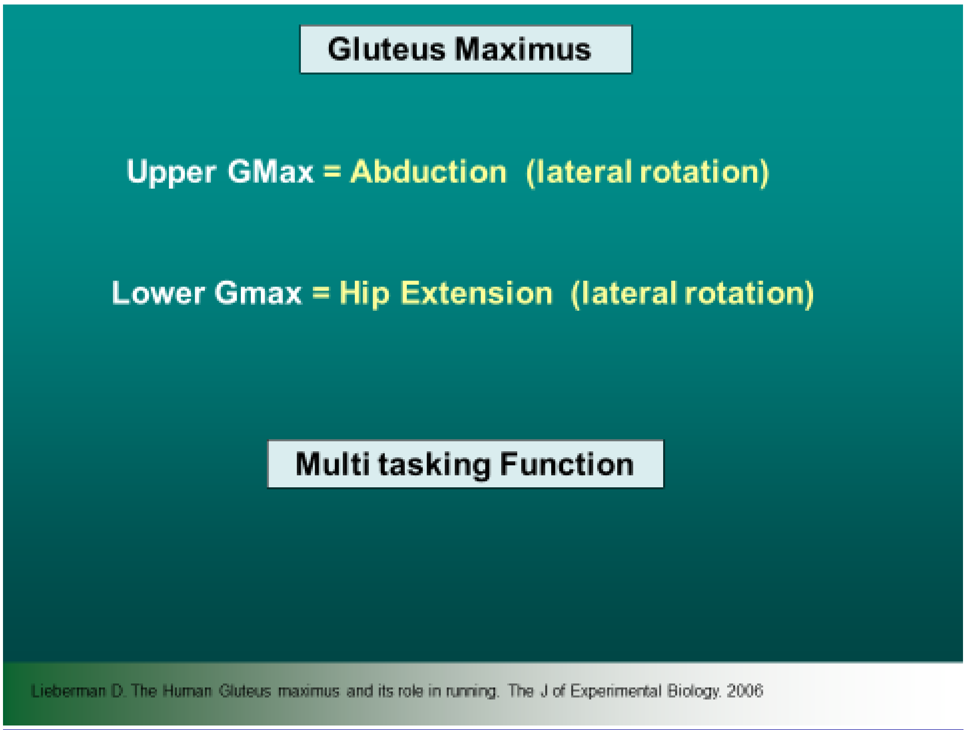
Gluteus Maximus

Slide 49

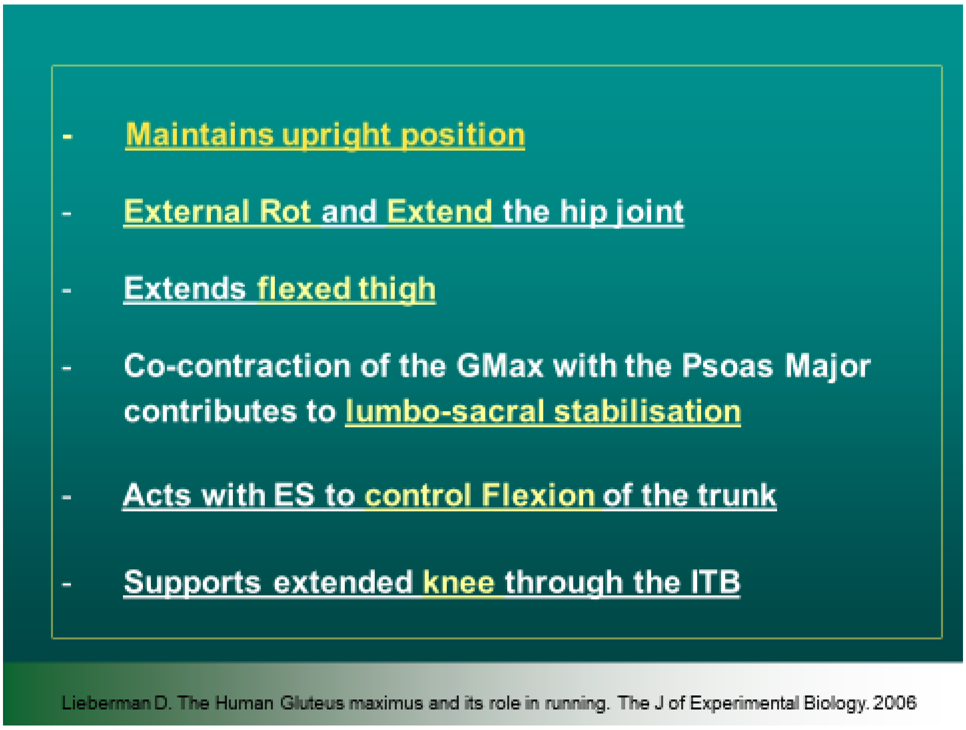


Slide 50

Slide 51

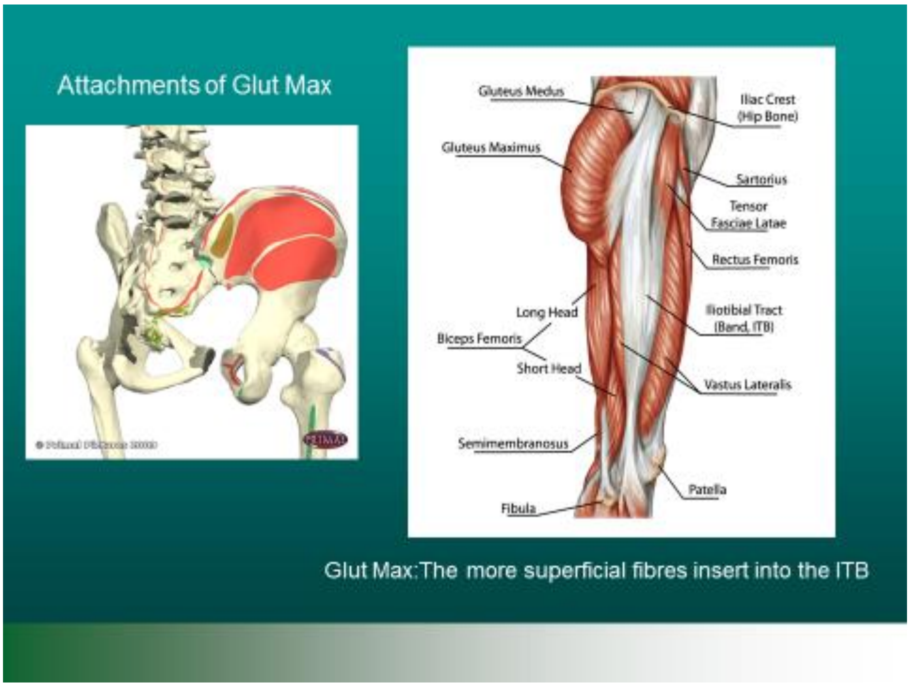


Slide 52



As specifically explained in Slides 49 to 52, Gluteus Maximus is the strongest muscle in the body and has a multi-tasking function, namely to maintain the upright position, perform external rotation and extension of the hip joint, extend the flexed thigh and support the extended knee through the ilio-tibial band. It also acts with the erector spinae muscles to control flexion of the trunk, as well as its co-contraction with the psoas major muscle contributes to lumbo-sacral stabilisation. Thus the role of the Gluteus Maximus is important for the biomechanics of the pelvic region, as well as the consequential effect on the entire kinetic chain (Liebermann, 2006). This role has largely been underestimated when analysing movement patterns, particularly regarding the different roles of various components of Gluteus Maximus (Lieberman et al., 2006). The distinct regions of Gluteus Maximus appear to have different roles in movement of the hip and pelvic region which needs to be seriously considered in the assessment and treatment of hip and groin patients

Slide 53



Slide 53 shows the different origins of the Gluteus Maximus as well as the interconnectedness of the Gluteus Maximus to other muscles and fascia. This all needs careful consideration when identifying any weaknesses or potential problems.

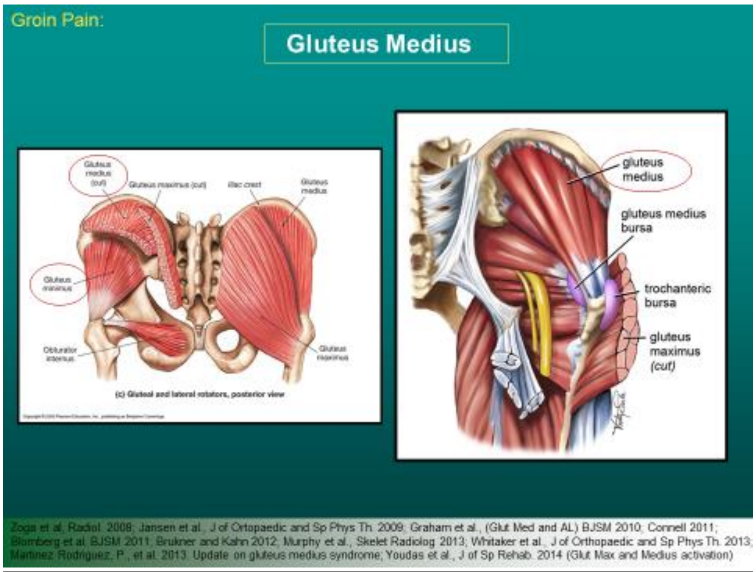
Grimaldi et al. (2009) highlights the functional separation of Upper Gluteus Maximus and Lower Gluteus Maximus and the similarities of the Upper Gluteus Maximus and Tensor Fascia Latae, both superficial abductors appearing to maintain their size around the affected hip in spite of any malfunction. This would suggest that the 2 components need to be assessed independently with specific rehabilitation provided for each part of the muscles and has been part of my approach with my athletes over these past years.

With this multi-faceted functionality and the interdependence of the kinetic chain, particularly the pelvic area and lower limb on the correct strength and performance of the Gluteus Maximus (as well as other Gluteal muscles), there is no doubt that targeting this muscle can have a major impact on prevention strategies. One has to consider that in this age, people are sitting for a large percentage of their day and thereby lengthening and thus potentially weakening the Gluteus Maximus muscle in specific ranges, which may impact on their performance in sport. This may then place extra pressure on the hamstrings and the lower lumbar spine. With more studies being produced and conferences highlighting the major role the Gluteii play in human movement, clinicians (including myself) have become more aware of the absolute importance of Gluteus Maximus, particularly in the athletic domain (Andersen et al., 2018; McCurdy et al., 2018; Neto et al., 2019). This has been one of the major factors that has improved my rehabilitation protocols (plus prevention strategies) and I have shared the positive outcome at all my presentations.

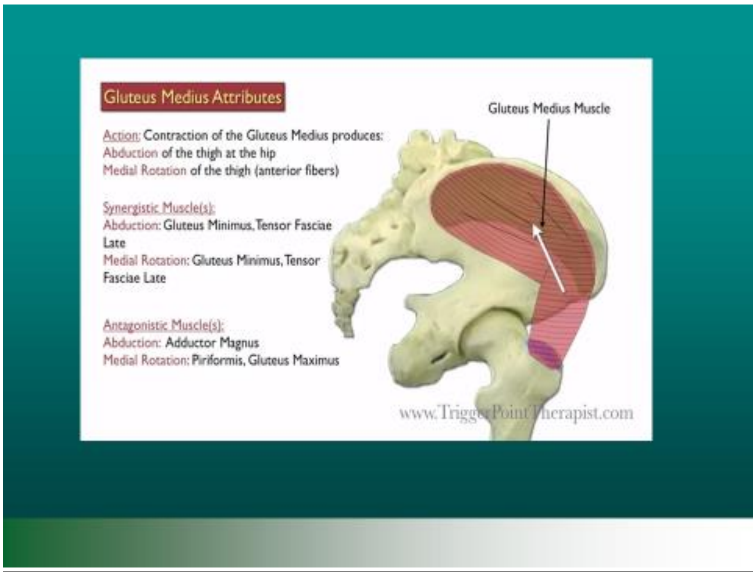
Gluteus Medius / Gluteus Minimus / Tensor Fascia Latae

As with Gluteus Maximus, Gluteus Medius, Gluteus Minimus and Tensor Fascia Latae are critical for stability and control of movement and are most important in the sports with different demands on the femoro-pelvic alignment (Retchford et al., 2013).

Slide 54

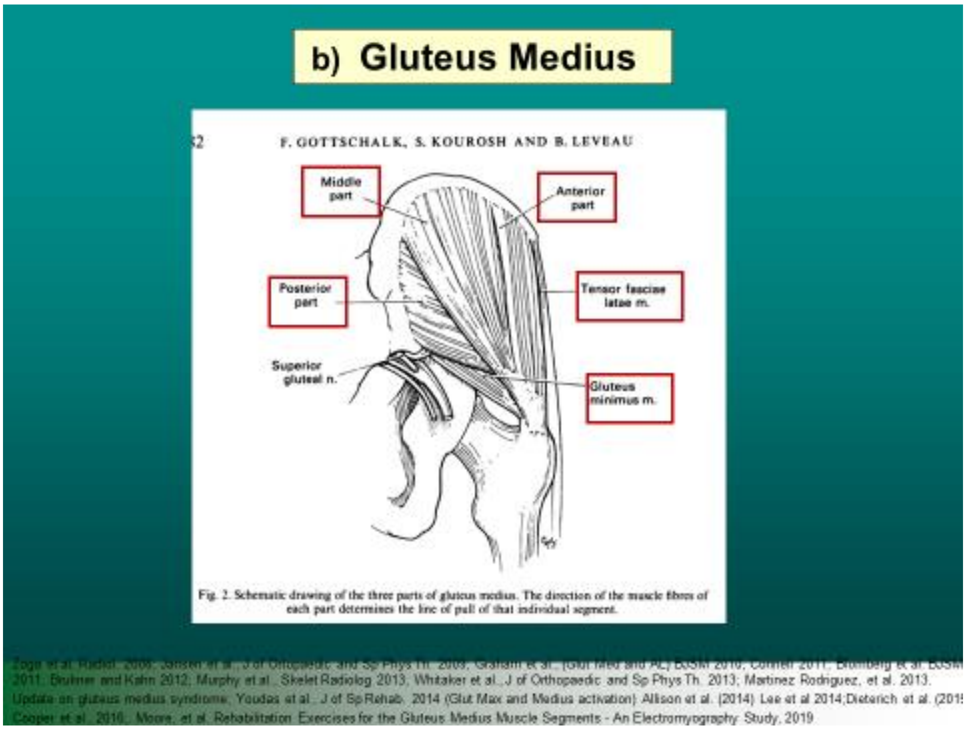


Slide 55

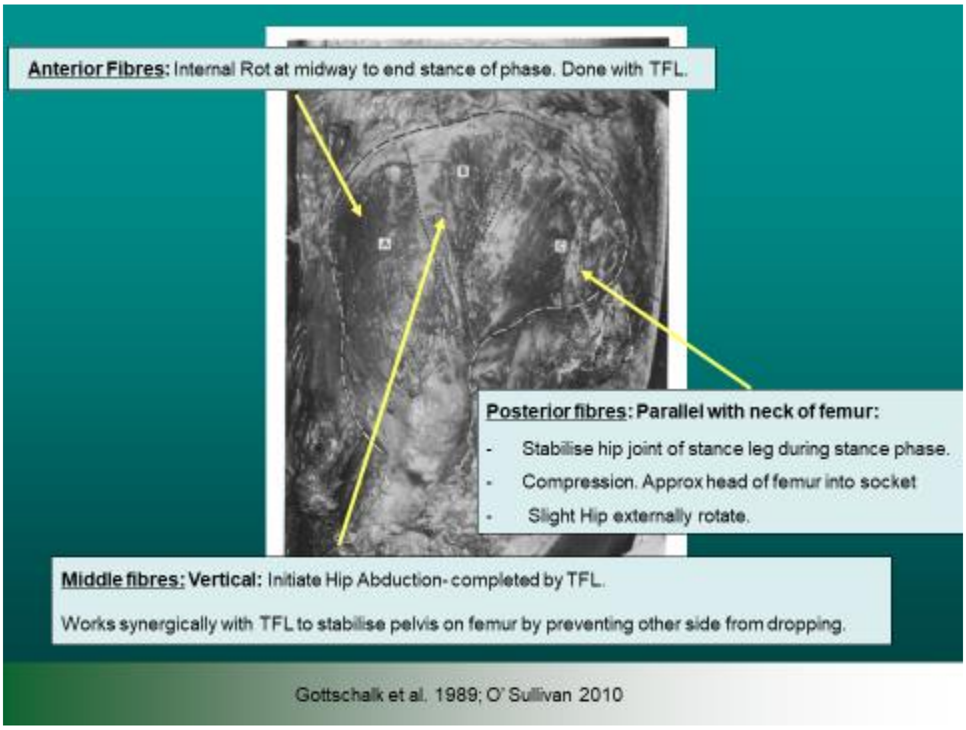


The role of Gluteus Medius and Minimus is very significant for pelvic stability and movement and its relationship with synergist and antagonistic muscles should be considered when managing athletes (Ebert et al., 2016; Neumann, 2010; Reiman et al., 2012) (Slides 54 and 55). This factor has been neglected in the past. My understanding of the integral role played my Gluteus Medius and Minimus in all body movements has developed over these past years and thus has allowed me to have a far more effective management in my clinical practice. This is not only with groin and hip pathologies, but most of the lower extremity. As with the Adductor muscles, the relevance of Gluteus Medius and Minimus has been a major factor in my presentations to all clinicians. It is enlightening to see the inceasing studies on Gluteal muscles over these past years.

<u>Slide 56</u>



Slide 57



As shown on Slides 56 and 57, there are clearly 3 different heads of Gluteus Medius. Gottschalk et al. (1989) demonstrated that each of these distinct heads performs a unique role as the body moves and was re-iterated by Grimaldi (2017). However, there is a lack of evidence to identify which exercises best activate the different parts Gluteus Medius (Grimaldi, 2017). This will be discussed further in the rehabilitation chapter.

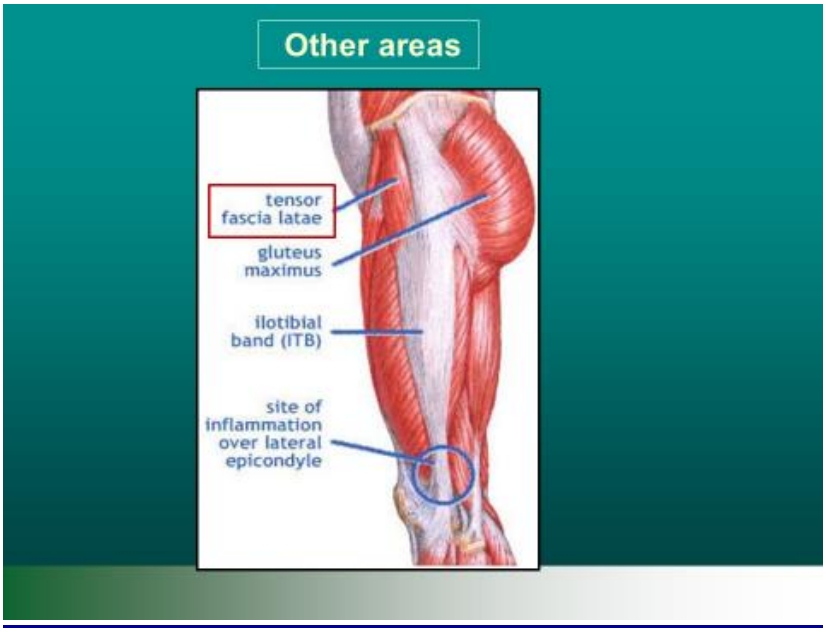
Slide 58

O'Sullivan et al. (2010) confirmed that the anatomically separate entities also function independently. They demonstrated the different functions of each part of the Gluteus Medius and concluded that the abductor mechanism was a system in which the Tensor Fascia Latae has the primary function of balancing the body weight and the non-weight bearing leg during walking. Gluteus Medius is responsible for the stabilisation of the hip joint in the initial phase of the gait cycle, as the main role of Gluteus Medius is to compress the head of the femur into the acetabulum during movement (Slide 58). O' Sullivan et al. (2010) concluded in their study, that the front portion of Gluteus Medius (anatomically similar to Tensor Fascia Latae) is most active at full stance phase and single leg support phase while rear fibres fire strongly at initial heel strike. Further, another relevant function of Gluteus Medius and Gluteus Minimus muscles is eccentric control of hip adduction during single-leg loading tasks (Allison et al., 2018). As the Gluteus Maximus is a primary external rotator of the femur with the leg in neutral position, hip abduction with extension reduces the Gluteus Maximus role as an external rotator and thus emphasizes the posterior fibres of the Gluteus Medius. Though currently rarely targeted in a rehabilitation protocol, the posterior fibres of the Gluteus Medius are unique and contribute to overall performance of the muscle. Strengthening of the Gluteus Medius improves lower extremity power, reduces future risk in the uninjured athlete, and improves rehabilitation in the injured athlete (Grimaldi 2015).

Clinicians need to analyse the different muscles with regards to stability in gait and thereafter careful consideration and specific examination should ensure that prescribed rehabilitation is targeted at specific muscle dysfunctions. This will be followed up in Chapter 5 - Tests.

Thus my desire to share all this “newly” recognised information in my presentations.

Slide 59



The Tensor Fascia Latae works in conjunction with the Gluteus Maximus, Gluteus Medius and Gluteus Minimus in a wide variety of hip movements including flexion, abduction, and internal rotation (Trammell and Pilson, 2019) (Slide 59). A very important factor which is being discussed more recently at hip conferences, is that Tensor Fascia Latae is significantly more active in isolated hip abduction, rather than Gluteus Medius and Gluteus Minimus (Grimaldi, personal communication, May 5, 2017). Although Tensor Fascia Latae is not generally considered a posterior pelvic muscle, it is important to the gluteal muscle group because of its contribution to abduction. Further, like the Gluteus Medius and Gluteus Minimus, it acts via the iliotibial band's attachment to the tibia to assist in knee flexion and lateral rotation. The Tensor Fascia Latae is most important clinically for assisting in pelvis stability while standing and walking. In my practice, as with most clinicians, I have not realised the implications as mentioned. Thus I now understand the precise strengthening of Gluteus Medius, compared with Tensor Fascia Latae.

The implications of deficits in hip abductor muscle morphology, strength, activation patterns and functional control of the pelvis on the femur have been associated with other pathologies e.g. osteoarthritis of the hip (Arokoski et al., 2002; Grimaldi et al., 2009; Sims et al., 2002), medial compartment tibio-femoral OA (Chang et al., 2005), patellofemoral joint pain (Cowan et al., 2009; Mascal et al., 2003), iliotibial band syndrome (Fairclough et al., 2007; Fredericson et al., 2005) and low back pain (Cooper et al., 2016; Marshall et al., 2011).

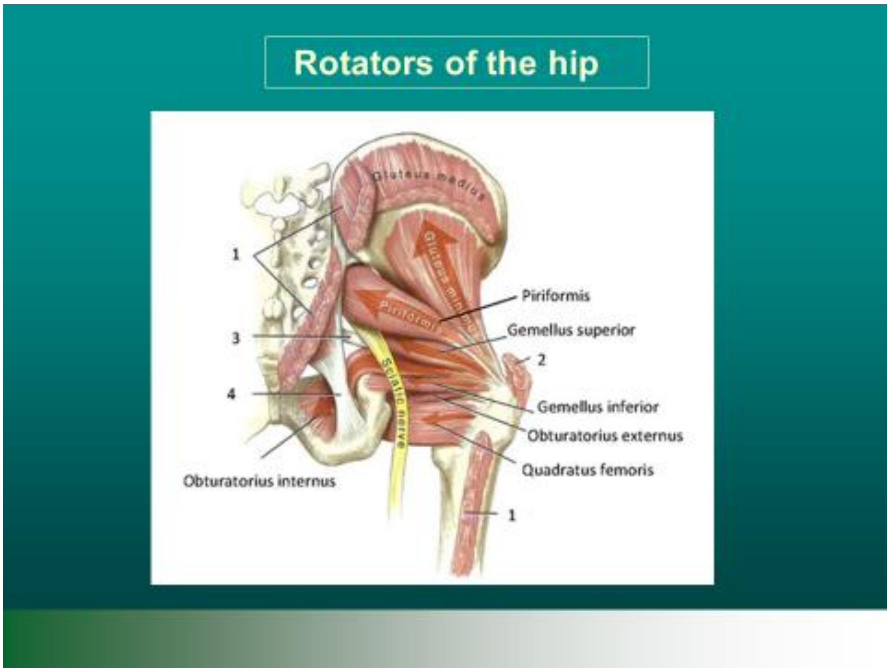
Thus, as clinicians, we need to understand the difference between the basic anatomical function and the possible mal-adaptations that can occur when there is weakness or a pathology which may affect joints and muscles along the entire kinetic chain. This lack of understanding may relate to lack of precise education, as well as sufficient analysis and implementation in our clinical practice. In addition, the basic muscle actions determined from anatomical attachment are far more complex and can change relative to weight-bearing status or range. The ongoing activation of hip muscles may play an important role in augmenting the stability in the normal and the passively unstable hip.

Conclusion – Glutei muscles and Tensor Fascia Latae

I believe that this section is one of the most important aspects of my presentations as it is the basis for prevention and rehabilitation of all athletes with groin and hip pain. As stated, I personally have learnt a great deal regarding the relevance and permutations of the individual Gluteal muscles on the journey of writing up this Professional Doctoral thesis. I believe that I have contributed more successfully to my athlete's recovery post groin or hip injury (plus the assistance to all my Anterior Cruciate ligament reconstruction patients who have benefited by strengthening the Gluteus Medius and Minimus muscles). I now specifically perform Glutei muscle prevention strategies based on this acquired information. Generally, more clinicians have also identified the importance of the Glutei muscles and their role in the kinetic chain. Essentially, I would advise certain exercises for these muscles to be done by all athletes as a matter of course and as a prevention strategy. My approach now differs to my previous management and I see a much more positive outcome amongst my patients with groin and/or hip pain.

3b iv. Hip Anatomy: Hip Rotator Muscles

Slide 60



Slide 60 explains that local hip muscles (quadratus femoris, Gluteus Minimus, gemelli, obturator internus and externus, iliocapsularis and the deep fibres of iliopsoas), rather than global muscles provide subtle joint compression and thereby limit translation of the hip and augments stability (Grimaldi, 2015). Interventions aimed at restoring isolated neuromuscular function of the primary hip stabilisers may be considered when treating people with passive hip instability prior to commencing global muscle rehabilitation.

Awareness of any pathology that may compromise the passive stability of the hip joint e.g. acetabular labral injury which may lead to increased femoral head translation, greater joint contact pressures and ultimately the possibility of degenerative hip disease such as hip acetabular lesions, is essential.

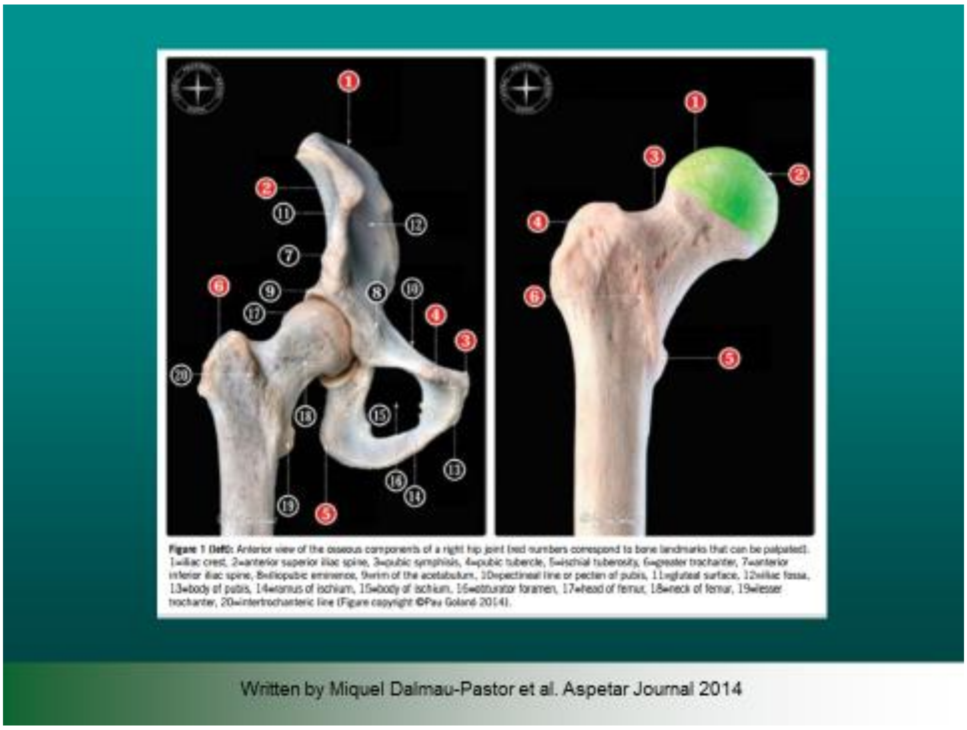
There may be changes in the muscle morphology around the hip and the pelvic region when there are any abnormal or degenerative structural changes (Grimaldi et al., 2009). As we are aware, there are many asymptomatic structural changes in the hip and around the pubic area in Premier League footballers (Lovell et al., 2006). This is apparent from my work with the Premier League over the past years and has been stated many times at groin and hip conferences e.g. Griffin (Arsenal Conference, London, United Kingdom, 2016). This increased uptake around the pubic joint is as a result of load and I now understand that it is not necessarily a pathology, although one should be aware of a possible pathological outcome if excessive load continues. This has shifted my thinking from the previous incorrect "Osteitis Pubis" to prevention, if excessive bone marrow oedema is noted.

The study by Grumet et al. (2010) reviewed the relevant anatomy and pathophysiology of the lateral hip. They recommended a systematic approach to assessment that includes the differential diagnosis of referred pain and systemic illness. MRI may be helpful to rule out soft tissue pathology, such as tears of the gluteus insertion on the greater trochanter.

3b v. Hip Anatomy: Hip Joint

The human hip joint withstands high contact forces during daily activity and is therefore susceptible to injury and structural deterioration over time (Correa et al., 2010).

Slide 61



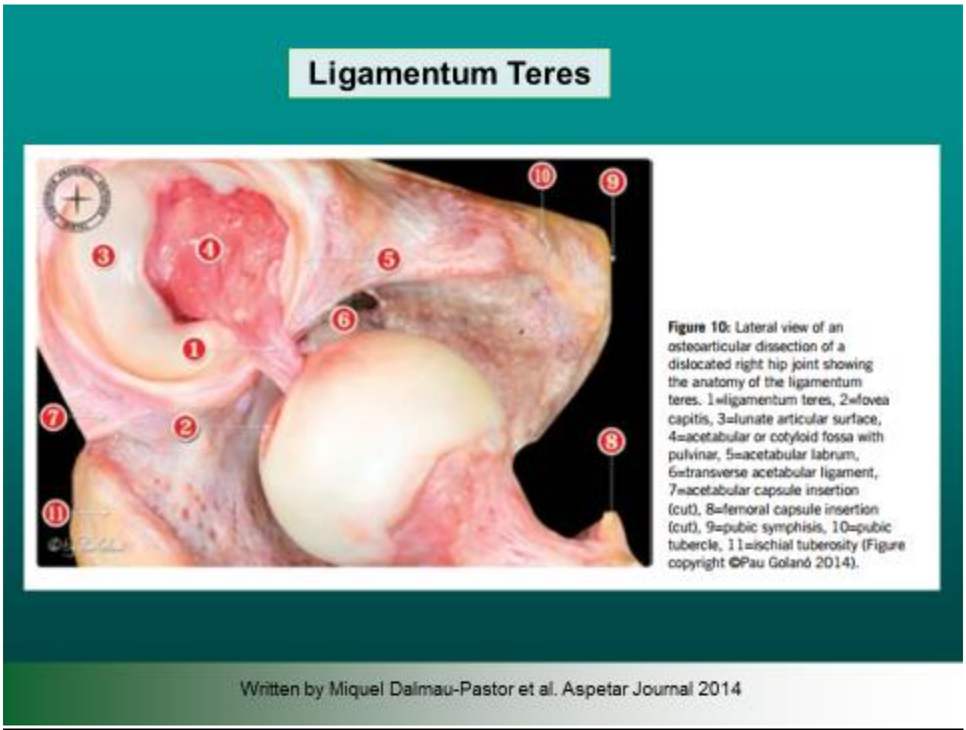
Miquel Dalmau-Pastor et al. (2014) explains the hip anatomy in a concise and applicable manner (Slide 61). Hip joint pathology is one of the main causes of groin pain but was not necessarily highlighted in earlier studies (Holmich et al., 1999). As shown by Rankin et al. (2015), hip joint pathology was the leading cause of groin pain in a review of 894 cases and was most likely related to FAI, labral tears, and osteoarthritis. They hypothesised that these pathologies seem to be associated with secondary breakdown of surrounding structures, although underpinning mechanisms remain unclear.

The capsule of the hip joint is an important stabiliser of the joint. In addition to the stability provided by the osseous anatomy, the soft tissues surrounding the hip joint are important for stability. There are four ligaments surrounding and reinforcing the capsule joint. The ilio-femoral and pubo-femoral ligaments and the zona orbicularis are found in the anterior region of the hip joint, whereas the ischio-femoral ligament is located in the posterior region. The ilio-femoral ligament is the largest and thickest of the three capsular ligaments and one of the strongest ligaments in the human body. Furthermore, the hip contains an intra-articular ligament, the Ligamentum Teres. However, there is ongoing debate regarding the specific structure and function of the hip ligaments. Although their exact role in stability may not be clear, their importance in stability is undisputed.

From an anatomical point of view, it is important to note that the capsular ligaments of the hip provide more hip rotational restraint than the acetabular labrum and the Ligamentum Teres (Van Arkel et al., 2015).

3b vi. Hip Anatomy: Ligamentum Teres

Slide 62



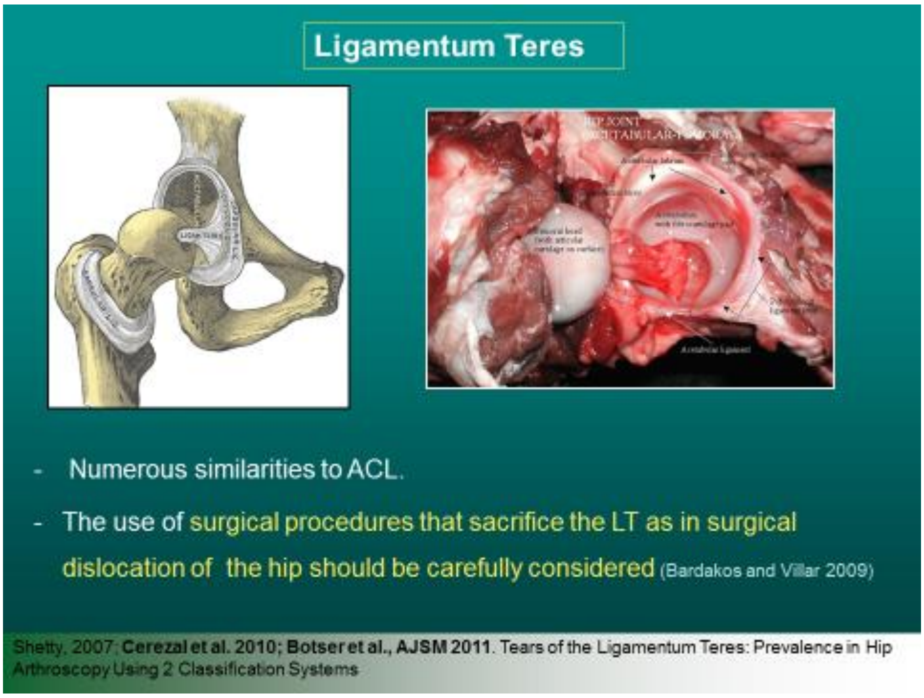
The Ligamentum Teres or ligamentum capitis femoris is an intra-articular ligament that attaches the femoral head to the acetabulum (Slide 62). Rupture of the Ligamentum Teres occurs usually with dislocation of the hip joint, although rupture may also occur in a twisting injury. A relationship between micro-instability of the hip and abnormalities of the Ligamentum Teres have been described as a further differential diagnosis to be considered with hip pain (Dalmau-Pastor, 2014).

Studies regarding the functionality of the Ligamentum Teres have been described by a number of authors (Kivlan et al., 2013; Martin et al., 2012; Perumal et al., 2016) with considerable inconsistency in the naming and description of the Ligamentum Teres morphology. The Ligamentum Teres has been shown to contain free nerve endings thought to indicate both a proprioceptive and nociceptive role for the ligament which is most important for prevention and rehabilitation of the groin and hip areas following damage to the Ligamentum Teres ligament (Sarban et al., 2007). This factor should be considered when an asymptomatic Ligamentum Teres tear is shown on a pre-screening investigation. As well as its potential role in hip stability, Gray and Villar (1997) suggested a possible role for the Ligamentum Teres in synovial fluid circulation. However, there is a paucity of evidence supporting this theory.

The Ligamentum Teres has traditionally been viewed as an embryonic remnant with no role in the biomechanics or vascularity of adult hips. However, it is a strong intra-articular ligament that is anatomically and biochemically similar to the anterior cruciate ligament of the knee and is an important stabilizer of the hip, particularly in adduction, flexion, and external rotation which is a common movement in a number of sports. A classification for Ligamentum Teres tears has been of great value for meaningful awareness of the disorders, especially as Ligamentum Teres tears were found to be correlated to larger labral tears and to higher-grade acetabular chondral damage (Cerezal et al., 2010 and Gray and Villar, 1997). These 2 injuries would have a significant impact on hip stability.

The importance of the Ligamentum Teres and its possible connection to patients with FAI and labral pathology was highlighted by Chahla et al. (2016). They stated that isolated cam or isolated pincer were seen more often in hips with torn Ligamentum Teres than in hips with normal Ligamentum Teres. Although complete tears of this ligament were rare, they were associated with hip laxity and chondral defects of the femoral head. This would have implications for hip and pelvis stability. Mayes et al. (2016) note that there was a higher frequency of Ligamentum Teres tears in professional ballet dancers (55 %) compared with athletes (22 %). This higher frequency of atraumatic tears in these dancers suggests that the Ligamentum Teres might be abnormally loaded in ballet, and one should be cautious when evaluating MRI, as these tears may be asymptomatic. Conversely an asymptomatic Ligamentum Teres tear may cause resultant hip instability which may underpin further hip or groin pathology. This should be born in mind when managing any sports with similar loading e.g. ice hockey and gymnastics. Although the identification of this Ligamentum Teres tear is the role of the Specialist, as a physio, I am acutely aware of these discrepancies and work closely with the Specialist to identify the possible disruption caused by the ligament tear.

Slide 63



Treatment of these lesions are now evolving with more caution regarding surgical procedures (Cerezal et al., 2010 and Wenger et al., 2008). Philippon et al. (2012) re-affirmed the importance of the Ligamentum Teres and stated that the traditional view that Ligamentum Teres did not contribute to mechanical stability was changing, and clinical procedures were aimed at preserving the ligament (Slide 63). Even with a rupture of this ligament, which may cause symptomatic hip instability during athletic activities, they undertook an arthroscopic reconstruction of the Ligamentum Teres using iliotibial band autograft in an attempt to restore this static stability.

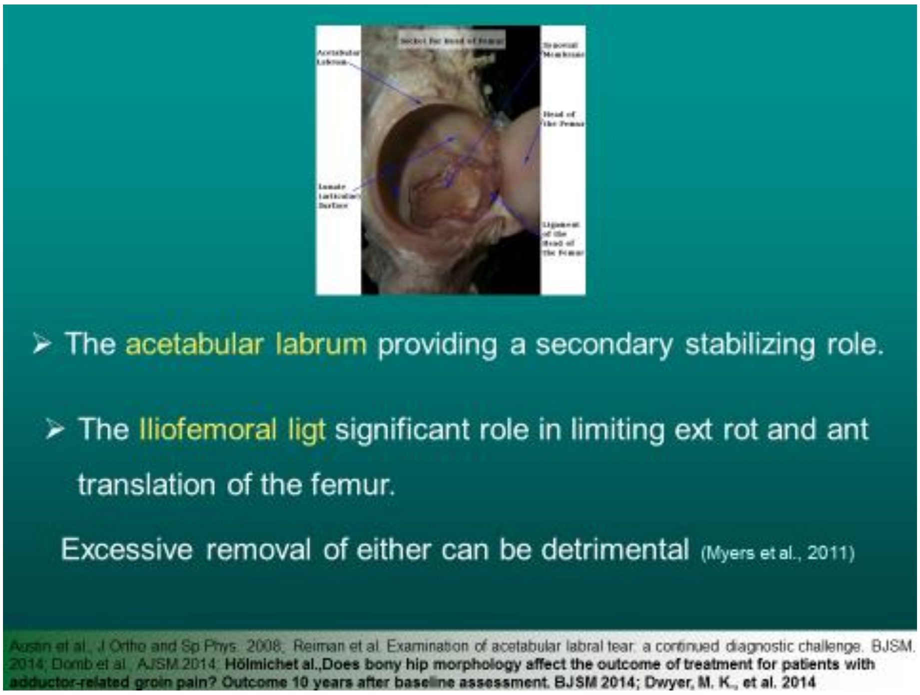
To date, the proposed mechanisms of injury to the Ligamentum Teres comprise traumatic injury, iatrogenic injury sustained during open surgical dislocation and repetitive 'microtrauma' often associated with hyperlaxity. Domb et al. (2013) reviewed the relationship of Ligamentum Teres tears with acetabular morphology and its significance and found that the presence of these tears was associated with acetabular bony morphology and age. They declared that further study is needed to establish whether there is a causal relationship between acetabular under-coverage and Ligamentum Teres tears and whether these tears may be a sign of micro-instability of the hip.

The importance of Ligamentum Teres was further confirmed with studies by Baek et al. (2018); Bardakos and Villar, (2009); Botser et al. (2011); Byrd and Jones, (2004); de SA et al. (2014); O'Donnell, (2014); Park et al. (2019) and Porthos et al. (2015).

3b vii. Hip Anatomy: Acetabular Labrum

The acetabular labrum is a soft-tissue structure which lines the acetabular rim of the hip joint. Its role in hip joint biomechanics and joint health has been of particular interest over the past decade. In normal hip joint biomechanics, the labrum is crucial in retaining a layer of pressurised intra-articular fluid for joint lubrication and load support/distribution. Its seal around the femoral head is further regarded as contributing to hip stability through its suction effect. The labrum itself is also important in increasing contact area thereby reducing contact stress (Bsat et al., 2017).

Slide 64



Joint position was shown to strongly affect the sealing function of the labrum and was attributable to the distance between the labrum and femoral head in certain positions. Thus altering the relationship between the labrum and femoral head may disrupt the sealing ability of the labrum, potentially leaving the joint at risk for pathological changes with time (Dwyer et al., 2014) (Slide 64) This was shown clearly by Ollivier et al. (2017) whereby they demonstrated that the morphological variations of the mid-portion of the labrum during hip motion reflected strains passing from the labrum to the femoral head. Those elements may provide clues to understand the mechanical role of the labrum during abduction. Thus I concur with Ollivier et al. (2017) who states that one should consider that resecting the hip's labrum during surgery might be detrimental for hip joint's biomechanics, as it might cause strain distribution between the acetabulum and femur.

Slide 65

Slide 66

Slides 65 and 66 demonstrates the presentation by Grimaldi (PhysioUK, London, UK. 2015) who clearly explained the number of mechanisms that can lead to labral injuries and the resultant stresses imposed on the hip joint. The problem for clinicians is in determining when these labral injuries become symptomatic and whether one needs to intervene to prevent any problems. It has always been my clinical objective to screen for these factors with the use of a battery of tests and where possible to provide pre-rehabilitation, as evidence regarding the clinical implications has not been forthcoming. Understanding the anatomy of the labrum has led me to consider these findings seriously and to intervene with preventative rehabilitation as shown in Chapter 11.

Mayes et al. (2016) identified asymptomatic labral tears in 51% of all 196 hips of their ballet participants. The prevalence of labral tears in male and female ballet dancers was similar to that of a sporting population. Further, they highlighted that labral tears were not associated with clinical findings but were related to cartilage defects. Thus they cautioned clinicians when interpreting MRI findings of a labral tear which may not be the source of the symptoms. However, because of the ripple effect of a labral tear, when a labral tear is discovered on a pre-signing / screening protocol, the clinicians must be aware of these permutations and strengthen the hip and adjoining muscles accordingly to prevent any further damage. The debate continues regarding conservative or surgical management. I believe in the positive outcome of conservative treatment and thus implement conservative exercises which I believe makes a considerable difference in potential or current hip and groin pain.

The clinician should also take into consideration the required hyper-flexible hip in certain sports e.g. the dancer and the gymnast. Because of the extreme hip motion required and the compensatory soft tissue laxity in dancers and gymnasts, these athletes may develop instability, impingement, or combinations of both. Although dysplastic morphology was common in both sexes, it was somewhat more prevalent in females (Weber et al., 2015).

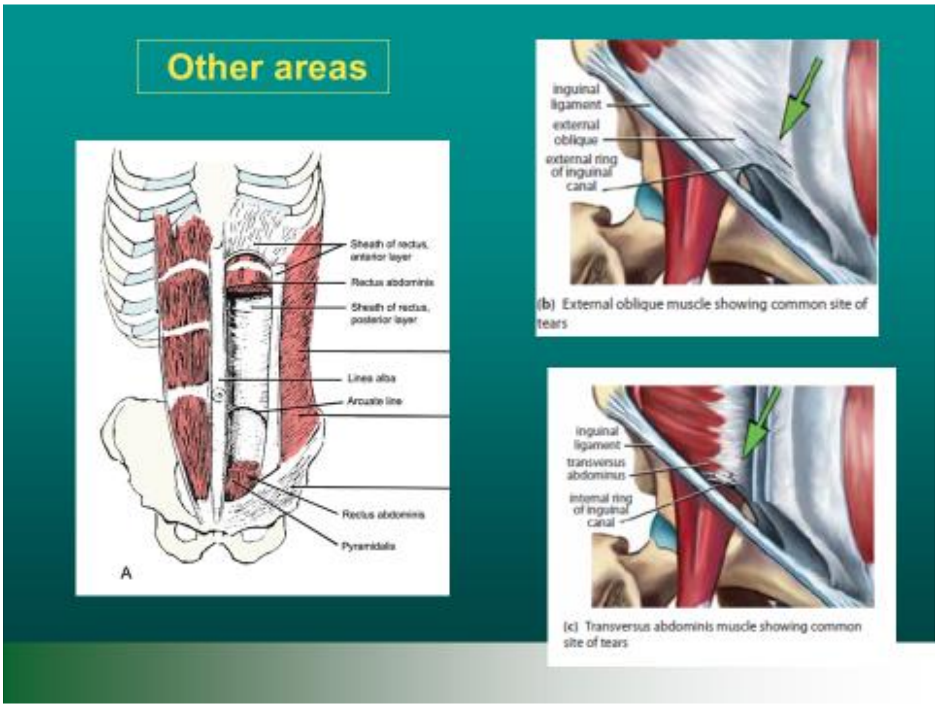
Conclusion: Hip Anatomy

Hip pain, commonly seen in active individuals, is one of the leading causes of pain and disability and is the second most common cause of lower limb musculoskeletal pain, (Kemp et al., 2019). The role of the hip rotator muscles and the acetabular labrum cannot be underestimated. Also, abnormalities of the Ligamentum Teres account for 4% - 15% of sports-related injuries and should be considered in the differential diagnosis of patients with hip pain. I believe that an analysis and interaction with the Specialist for possible required surgery for these hip pathologies may be instrumental in good clinical management. This is a key component in my approach for management of groin and hip pain.

The hip is a joint that can be affected by high number of pathologies, either intra-articular or extra-articular and recognition that hip pathology can produce groin pain is required for the accurate diagnosis of hip or groin related pain. It has become increasingly clear that unless a thorough understanding of the hip anatomy both structural and functional, with all the relevant consequences of various activities on the structures, is fully comprehended, a suitable prevention and management strategy is not possible. Where this insight has previously been underestimated, as time progresses there are increasing number of hip conferences with good interaction and a better understanding of the hip and all the permutations involved. I initially debated undertaking an entire thesis on hips, as there are a multitude of ongoing studies on the hip joint pathologies, as well as from my professional experience dealing with hips specifically. However, I reverted to the more generalised hip and groin for this thesis. This has been productive in my management of my sportsmen and women, as it has given me a better overview of the entire pelvic region. This has also led to more informative and helpful presentations that I have been giving to my colleagues.

3b viii. Transverse Abdominus

Slide 67



Another muscle which may be important with longstanding adduction-related groin pain is the Transverse Abdominus muscle (Cowan et al., 2004; Jansen et al., 2010) (Slide 67). The Transverse Abdominus is the deepest lateral muscle in the anterolateral abdominal wall, lying deep to both the internal oblique and external oblique, on either side of the rectus abdominis. It originates from the inguinal ligament, pelvis, lumbar fascia and lower ribs. Its parallel-oriented fibres run medially and insert on an aponeurosis connecting to the linea alba and pelvic crest, thus the importance to the entire kinetic chain. Any weakness or injury to this muscle may be a risk factor for acute and recurrent groin injury and may be another consideration for rehabilitation and prevention of longstanding adduction-related groin pain.

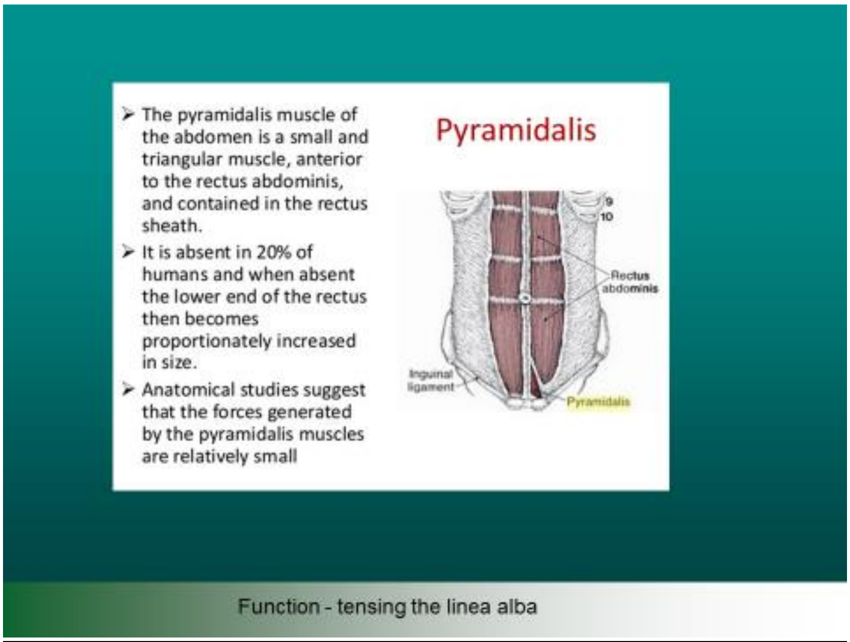
3b ix. Rectus Abdominus

The action of the Rectus Abdominus is to produce flexion of the lumbar spine and to act in opposition to the erector spinae muscles and thus is important for postural stability. Knowledge of the interconnectedness with the adductors at the insertion is crucial for management in certain sports and specific movements. According to Orso et al. (1990), the incidence of rectus-adductor strain would be around 2.5% - 3% and occurs mostly in sports like soccer, hockey, rugby, skating, fencing, running, cross country skiing and basketball (Paajanen et al., 2011). Valent et al. (2012) discussed insertional tendinopathy of the adductors and rectus abdominis and state that this is common in male athletes, especially in soccer players.

Athletic competition that involves hyperextension of the hip and trunk with twisting motions, such as kicking or a hockey slap shot generates tremendous forces across the common tendon attachment of the rectus abdominis and adductor longus tendons. Repetitive trauma or single episodes can result in strain or avulsion at this attachment. Historically, this was felt to be symptomatic inguinal canal insufficiency without true herniation, and treatment was based on standard hernia repair (Emblom et al., 2018). I have now become more cognisant of the extreme movements often required in a specific sport and the consequential muscle strength required.

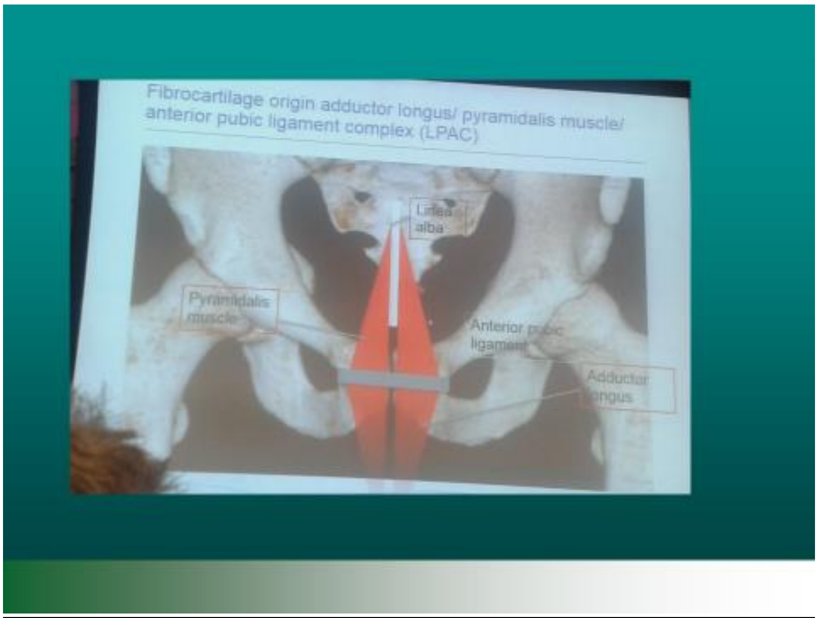
3b x. Pyramidalis

Slide 68



The paired pyramidalis muscles are small triangular-shaped muscles that lie between the anterior surface of the Rectus Abdominus and the posterior surface of the rectus sheath (Slide 68). The precise function of pyramidalis muscles is unclear, but together the muscles are thought to tense the linea alba. The muscles are not always present, can be unilateral, and vary greatly in size. The estimated forces generated by this muscle are relatively small (Lovering and Anderson, 2008).

Slide 69

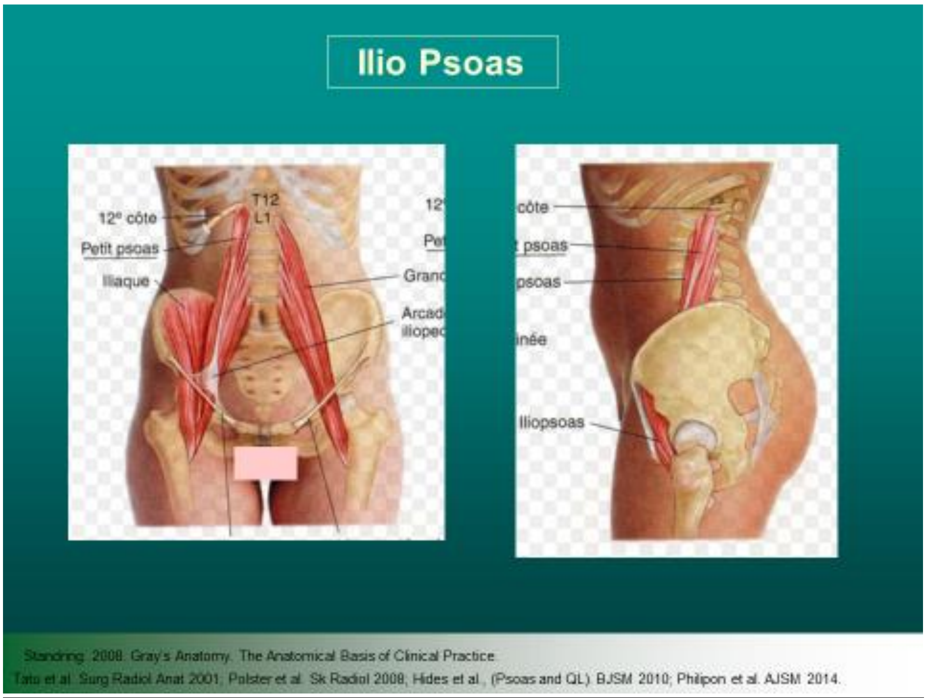


The importance of the pyramidalis muscle has been highlighted by Schilders, (Hip and Groin Conference, Doha, 2014) (Slide 69). Thereafter he explained the new anatomical concept of the pyramidalis-anterior pubic ligament-adductor longus complex and its involvement in adductor injuries (Schilders et al., 2017). They explained that this relatively new understanding of these anatomical relationships should be employed to aid in image interpretation and treatment planning with proximal adductor avulsions. This again highlights the relevance of clinicians constantly updating their knowledge in order to enhance their management of the athletes.

3b xi. Psoas and Quadratus Lumborum

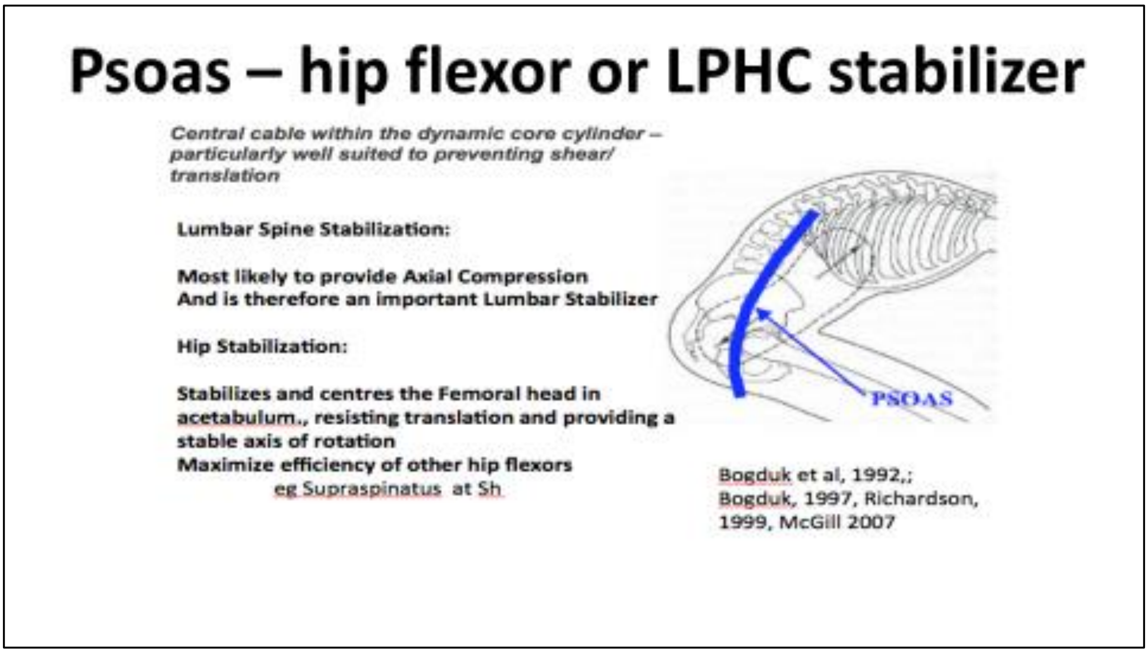
The psoas muscle is among the most significant muscles that overlies the vertebral column. At its distal end, it combines with the iliacus muscle to form the iliopsoas muscle. The deeper segment of the muscle originates from the first four lumbar vertebrae, while the superficial segment originates along the lateral surface of the distal thoracic vertebrae and from adjacent intervertebral discs. The inconsistent psoas minor muscle completes the psoas muscle. The common tendon attaches on the lesser trochanter of the femur: the muscle during contraction of the fibres leads to external rotation and abduction of the femur. The psoas major muscle has a biomechanical and postural function during both moving and static states (Siccardi and Valle, 2019). Due to its origin and insertion, it has influence on the lumbar spine, as well as the lower extremity.

Slide 70



The iliopsoas muscles are the strongest of the hip flexors (others are rectus femoris, sartorius, and tensor fasciae latae) and are important for standing, walking, and running (Anderson, 2016). This was explained in ballet dancers, where pain will reduce the increased size of the ilio-psoas muscle and thus may cause change in movement patterns and possible resultant groin or hip pathologies (Emery et al., 2019). I believe that the Iliopsoas muscles are a very significant part of body movement, particularly in the sporting world such as football or cricket fast bowling. Thus I have highlighted this in my presentations and even request that my attendees stand up and do the hip flexion test (as explained in the Chapter 5 – Assessment). It is thus interesting to note how weak so many of them are. This brings home the message to them of the importance of the functionality of these muscles.

Slide 71



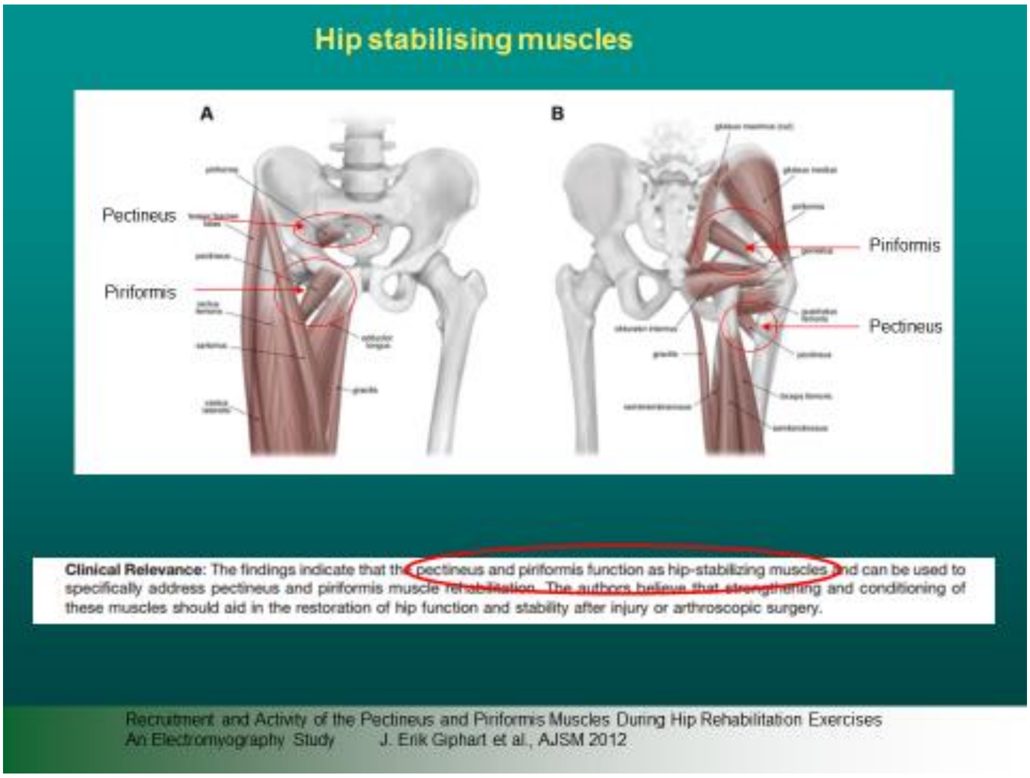
At the Football Medical Conference (May 2016), Wright explained the importance of the psoas muscle in its stabilising role around the Lumbo-Pelvic Hip Complex as shown clearly in Slide 71.

Hides et al. (2010) described the Psoas and Quadratus Lumborum muscle asymmetry among elite Australian Football League players. The fact that the cross sectional area of the psoas muscle was significantly greater ipsilateral to the kicking leg, while the cross sectional area of the Quadratus Lumborum was significantly greater on the side contralateral to the kicking leg was noted. While they found that asymmetry in muscle size was not related to number of injuries, the influence of kicking on the trunk anatomy must always be considered. Hides et al. (2017) also highlighted the decreased size of the multifidus muscle as being a predictive factor for lower limb injury in both the pre-season and playing season. I think it would be useful if these factors were taken into consideration when considering appropriate prevention and rehabilitation strategies in athletes with groin and hip pain and are currently part of my management approach.

Once again, from my experience in most elite sport where surgery is often the first recourse of action, prevention of surgical procedures is plausible, even though it requires time. The clinician needs to understand the basic structural and functional anatomy of these muscles and promote a specific strengthening and stretching protocol, as well as a prevention strategy by analysing any abnormalities pre-season where possible. Although this strategy sounds feasible, there is continued conflict in elite sports, where there is limited time for conservative mangement and surgery is undertaken promptly in order to get the player back to action as soon as possible. The medical saff are under pressure from the elite management personnel and often have to accept a “quick-fix” solution. I have given the medical staff in elite sports some assurance that a “quick-fix” is not the answer to groin and hip problems.

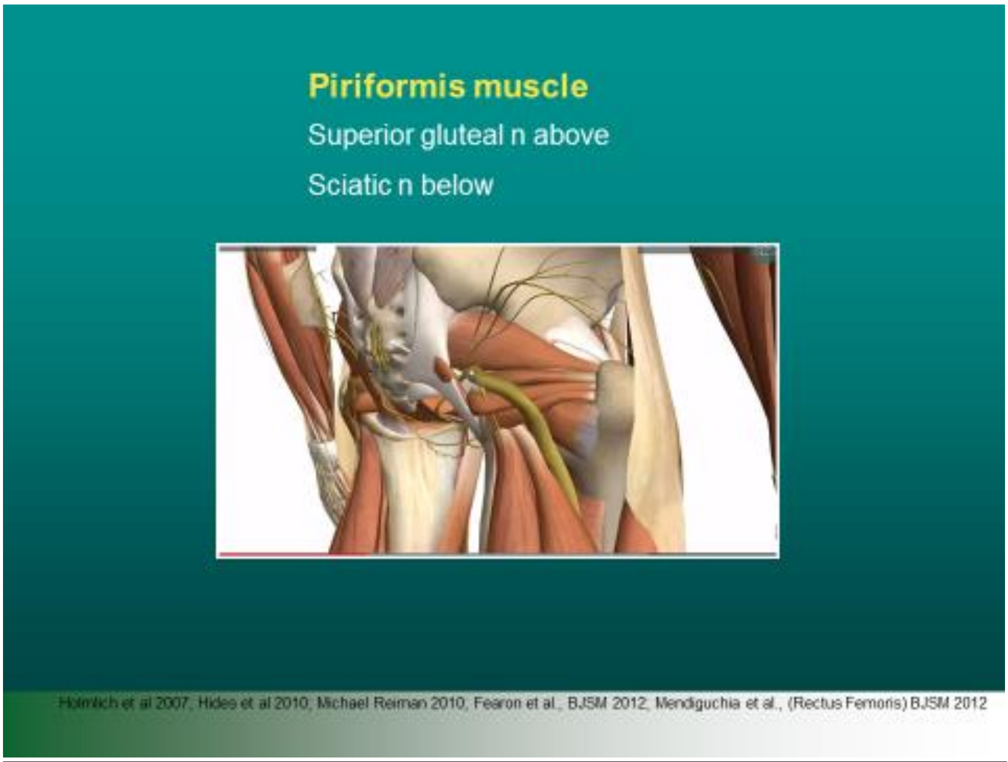
3b xii. Pectineus / Piriformis

Slide 72



Giphart et al. (2012) discussed the clinical relevance of the pectineus and the piriformis muscle in hip and groin pain (Slide 72). The pectineus has been reported to function primarily as a hip flexor and secondarily as a hip internal rotator and the piriformis muscle has been reported to function as an abductor and external rotator of the hip. Their findings indicated that the pectineus and piriformis function as hip-stabilizing muscles and suggest that strengthening and conditioning of these muscles could aid in the restoration of hip function and stability after injury or arthroscopic surgery. This knowledge has led me to re-evaluate and improve my approach for management.

Slide 73



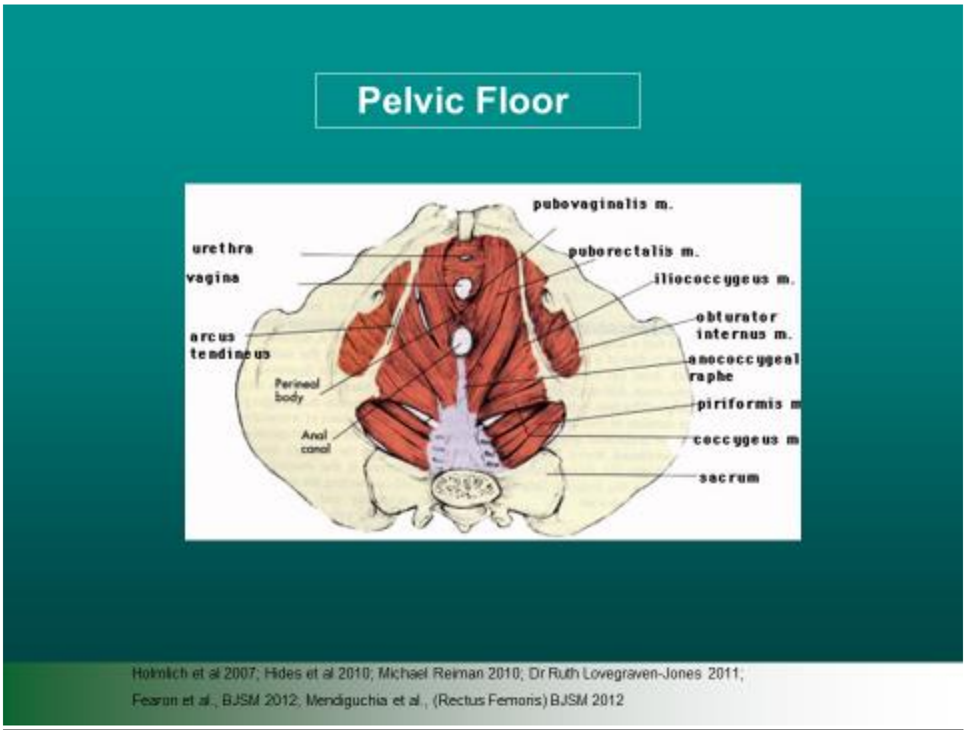
An understanding of the piriformis muscle and the so-called "Piriformis Muscle Syndrome" is essential for clinicians (Slide 73). Although Michel et al. (2013) suggested a spasm-type pain in which the sciatic nerve becomes compressed in the infra piriformis canal causing sciatic-type pain, in a commentary response, Palamar et al. (2015) stated that piriformis muscle syndrome must be distinguished from isolated buttock pain, in which the piriformis muscle can sometimes be incriminated, but the pathophysiologic features differ. Furthermore, many spinal or hip pathologies refer pain to the region of the piriformis muscle.

From my experience, I have found that many athletes such as runners, have very tight piriformis muscles which leads to potential mal-adaptations such as tight external hip rotators and possible subsequent hamstring problems.

This demonstrates the complexity and importance of stability of the pelvic girdle during all activities and an understanding of this intricate anatomical functionality is imperative

3b xiii. Pelvic Floor

Slide 74

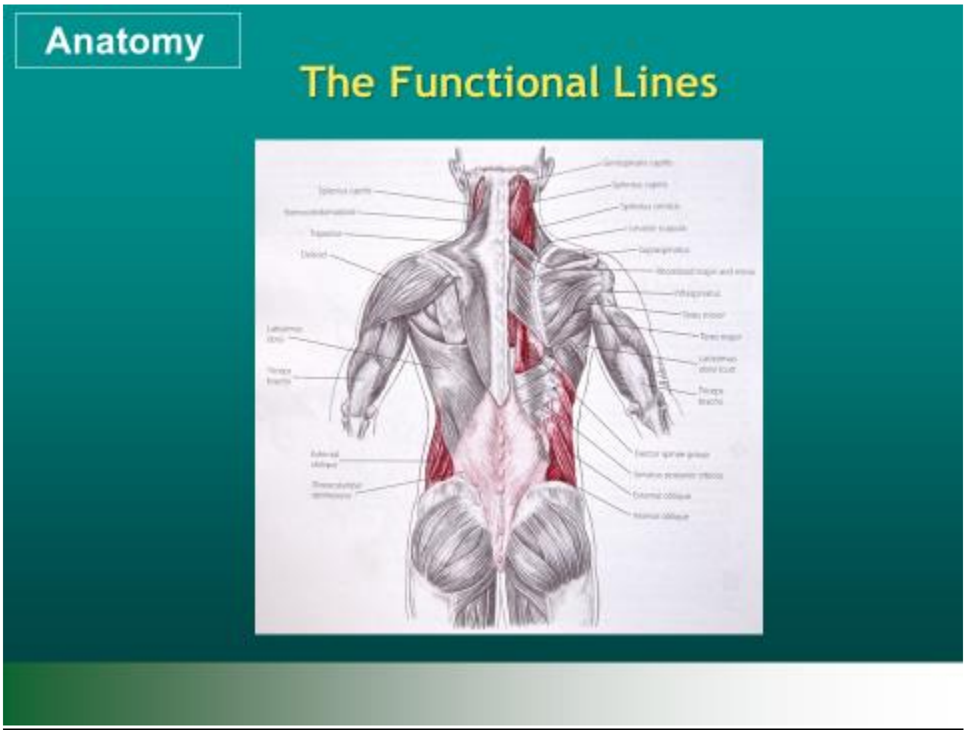


A presentation by Dr Ruth Lovegraven-Jones (Football Association Medical Society, London, UK. 2011) highlighted the involvement of the pelvis floor as a possible cause of groin pain, although not common (Slide 74). A case study by Podschun et al. (2013) demonstrated the interdependence of lumbo-pelvic and lower extremity kinematics in complaints of hamstring, posterior thigh and pelvic floor disorders. This shows the need to consider a regional interdependence of the pelvic floor and lower quarter when treating athletes and has had positive impact on my approach to groin / hip and possible related problems.

3b xiv. Fascia.

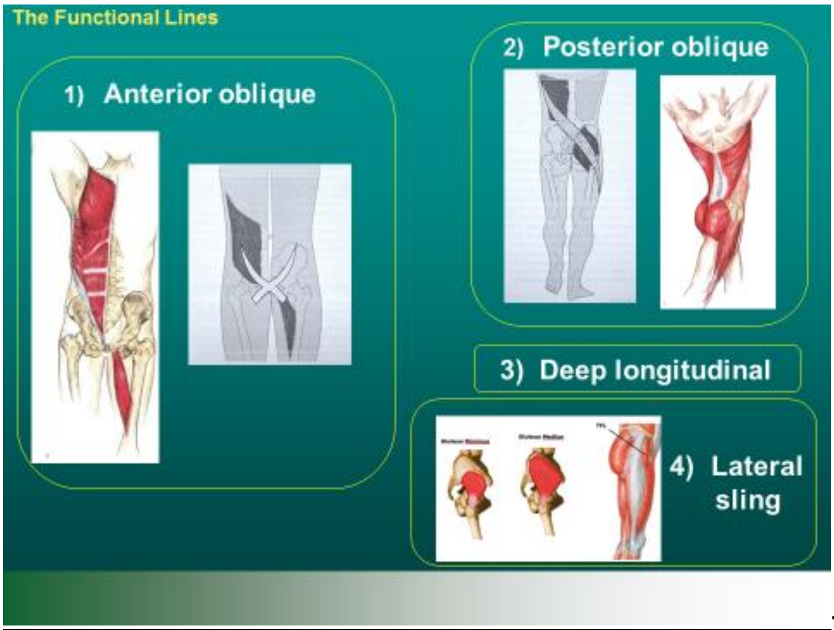
Fascia and its relation to the low back, pelvis and the entire kinetic chain, is a basic and often underestimated concept in medicine. The relevance of mutual interactions in relation to the low back and pelvis, as well as the entire kinetic chain has been undervalued, particularly with groin and hip management. When I trained in England in the early 1970s, special soft tissue massage of muscles and fascia was basic management of many pathologies (or for prevention strategies). With the development of electric and technological equipment, this was often sparingly used. Now functionality of fascia along the entire kinetic chain is slowly being recognised.

Slide 75



Fascia, also known as dense irregular connective tissue, forms a true continuity throughout our whole body (Slide 75). Fascia has been shown to be an important contributor to posture and movement organization and is densely innervated by mechanoreceptors and there are strong links between fascia and the autonomic nervous system which effect fascial tonus and local tissue viscosity (Schleip et al., 2012). However, compared with muscles, joints, and the nervous system, very little research has been devoted to the role of fascia in chronic musculoskeletal pain, particularly related to groin and hips. Detailed anatomical description of fascia has been highlighted in a number of studies (Barker et al., 2014; Findley et al., 2012; Vleeming et al., 1995; Willard et al., 2012; Zugel et al., 2018).

Slide 76



Slide 77

The fascia forms functional lines and a clear understanding of each functional line and the role that it plays in human movement is required (Slides 76 and 77). The interconnectedness of upper extremity to the lower extremity is directly through the pelvic fascia. Thus fascia itself may be an important factor in maintenance of joint stability and should be taken into consideration in the assessment and management of the groin and hip, particularly with athletes (Willard et al., 2012). In a Consensus statement it was highlighted that fascial tissues deserve more detailed attention in the field of sports medicine. A better understanding of their adaptation dynamics to mechanical loading as well as to biochemical conditions promises valuable improvements in terms of injury prevention, athletic performance and sports-related rehabilitation (Zugel et al., 2018). While the implications of this with respect to hip and groin pain are not clear, knowledge of these fascial lines requires consideration when assessing patients and possibly should also be linked with the previous discussion about the role of the Gluteus Maximus muscle in this kinetic chain.

Conclusion - Anatomy

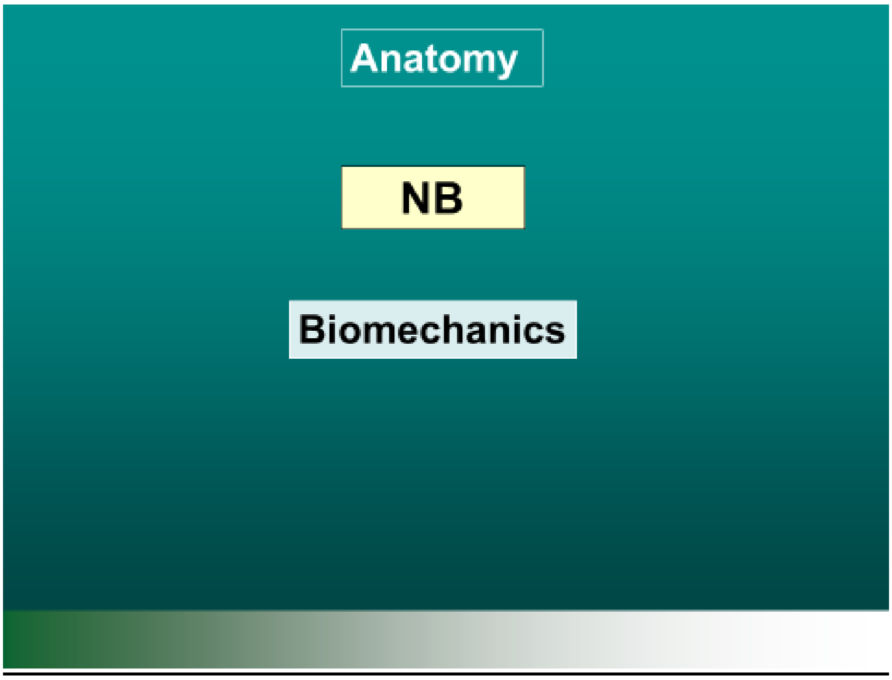
The assessment and the diagnosis of an athlete with groin and / or hip pain is a challenge for a clinician due to the complex anatomy, as well as the different structures that can refer pain around this area. The groin region, including the hip joint, where the abdomen meets the lower limbs via the pelvis, consists of musculoskeletal structures which require load transference between the upper body, trunk and lower limb and to provide a stable base in weight-bearing activities, as well as interaction of all movements (Brukner and Kahn, 2017). As shown in this chapter on anatomy which includes joints, muscles, ligaments and fascia, the complexity and understanding of the hip and groin anatomy is the basis of all correct management. A challenge here in synergies, means that as one muscle fails another takes over to ensure function isn't compromised.

Further information on the role of anatomy in the aetiology of hip and groin pain can be gained from a thorough understanding of the biomechanics of the hip and groin muscles which will be discussed in more detail in Chapter 4.

Chapter 4 - Functional Anatomy - Biomechanics

4a. Biomechanics - Background

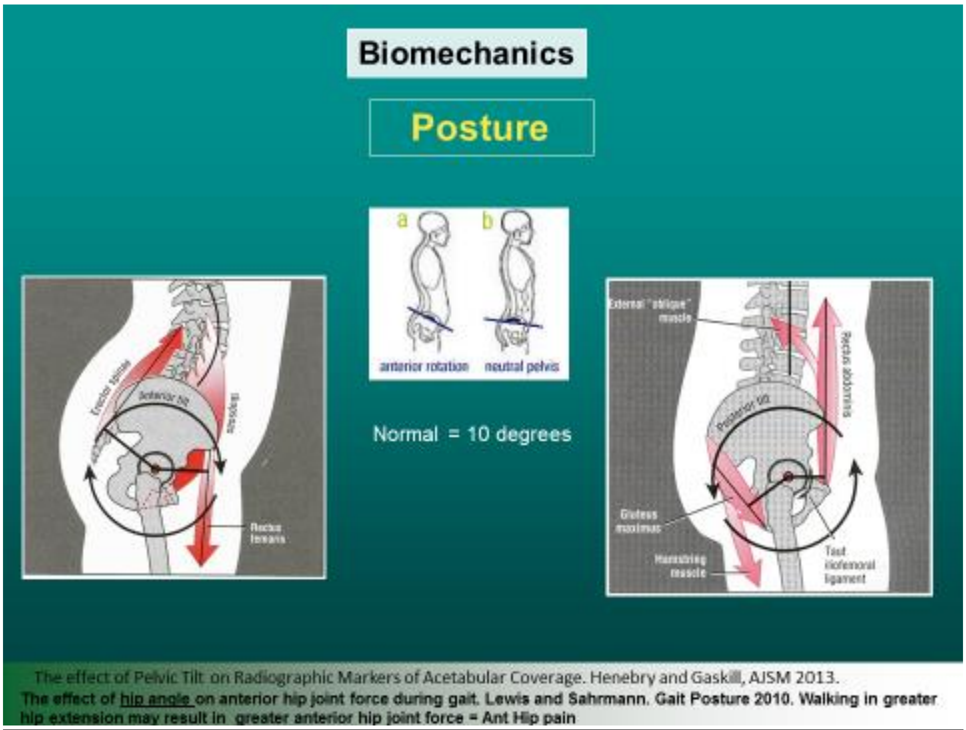
Slide 78



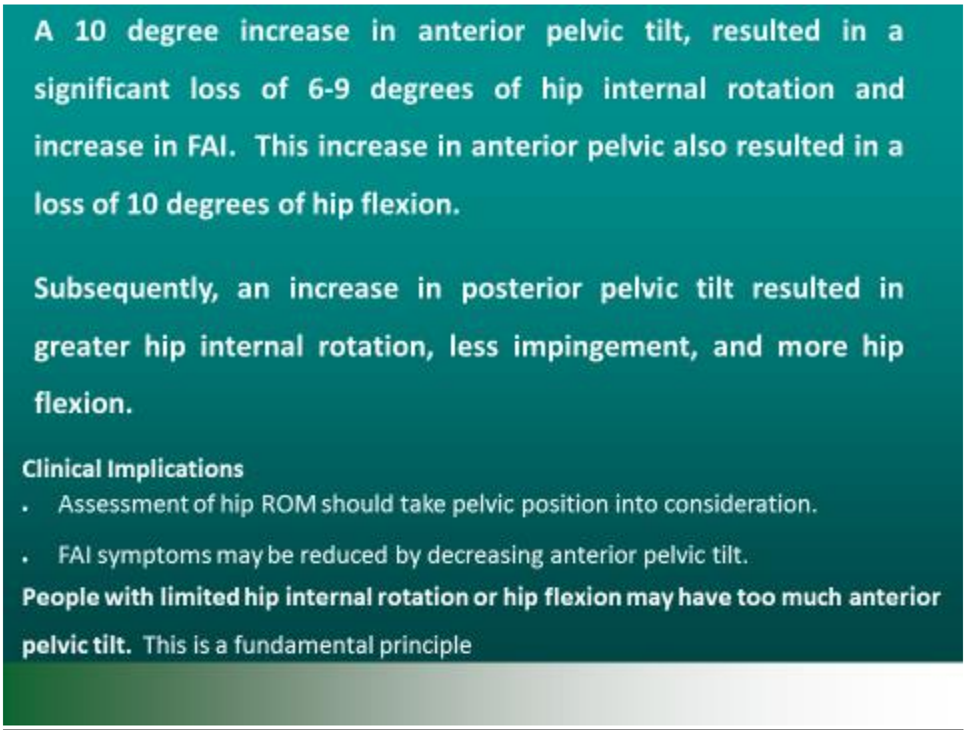
Biomechanics refers to the description, detailed analysis and assessment of human movement during both movement and sport in order to minimise the risk of injury and improve sports performance (Slide 78). Broadly, biomechanics can be broken into 3 categories, including kinematics, kinetics and neuro-motor control. Essentially, biomechanical evaluation should be completed based on task specificity, bearing in mind that each individual has their own individual mechanical make-up due to specific anatomical characteristics (Brukner and Kahn, 2017). Thus an in-depth knowledge of structural and functional anatomy (as per the preceding chapter), as well as informed analysis of static and dynamic movements for each situation, is imperative for clinicians. Physiotherapists, biokineticists, athlete trainers and strength and conditioning specialists require this knowledge to enhance the assessment and rehabilitation of the athlete. The role of biomechanical analysis in sports rehabilitation has changed during the course of my career and movement analysis has become a key component in my approach as a clinician and an educator.

4a i. General – Posture

Slide 79



Slide 80



It is only more recently that clinicians (including myself), have acknowledged that groin and hip problems are often related to deviations from normal posture (Slide 79). Most particularly the importance of the pelvic tilt and its implications on groin and hip mechanics is of interest (Slide 80). Historically, this has always been a guideline for the treatment of lumbar/sacral spine pathologies, as the axis of rotation has a significant impact on the form closure of the sacro-Iliac joint and may cause lumbar or sacro-iliac joint pathologies. However, as Slide 80 demonstrates, the effect of incorrect pelvic tilt on the hip joint has repercussions (Kanazawa et al., 2016; Workman et al., 2008).

As demonstrated by the evaluation of cadaveric hemipelvises (6 male, 2 female), there was a 10-degree increase in pelvic tilt results in a loss of 6-9 degrees of hip internal rotation and an increase in FAI (hip impingement). This increase in anterior pelvic tilt also resulted in a loss of 10 degrees of hip flexion (Henebry and Gaskill, 2013). This has important implications for all sports (and in activities of daily living). Further, limited hip extension flexibility due to tight hip flexor musculature or anterior hip capsular and ligamentous structures is a possible cause of increased anterior tilt of the pelvis during running (Schache et al., 2000). These dynamic changes in pelvic tilt may significantly influence the functional orientation of the acetabulum, which may have an effect regarding FAIS or hip morphology (Ross et al., 2014).

Furthermore, altered posture of the pelvis can influence the length-tension relationship of Gluteus Maximus and therefore reducing its stabilizing capacity. Associated with hip flexor tightness and local core weakness the anterior tilted pelvis can elongate the Gluteus Maximus and thus place the muscle in a mechanically disadvantaged position (Buckthorpe et al., 2019).

Essentially, when managing a patient, it is important to take cognisance of the pelvic position both statically and dynamically.

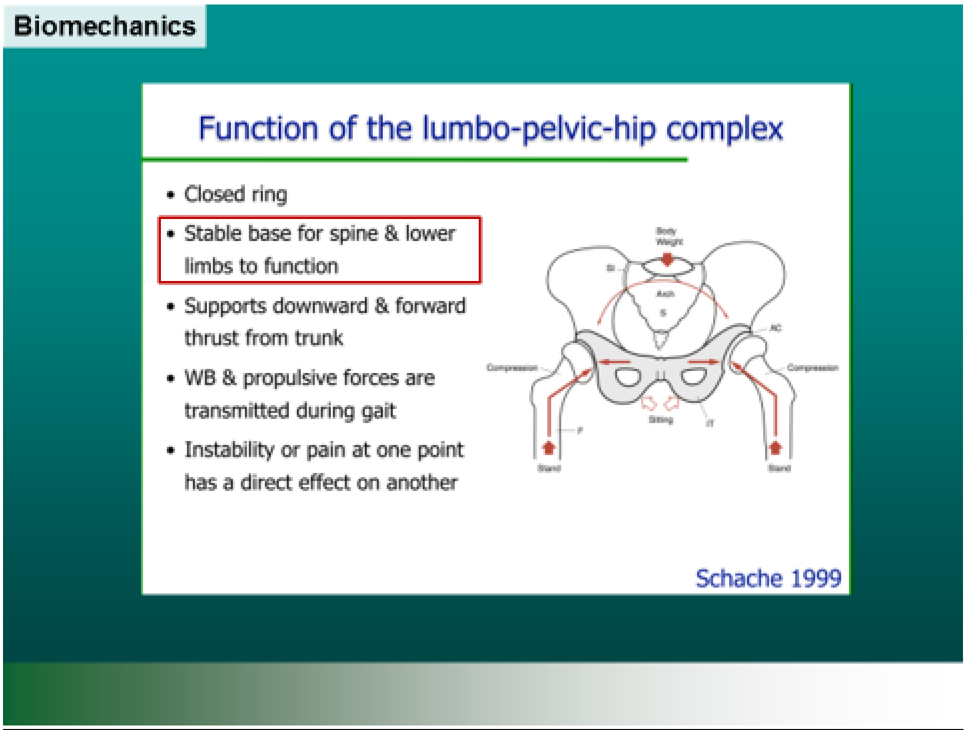
4a ii Load – Joints and muscles

Load is defined broadly to include rapid changes in training and competition load, competition calendar congestion, psychological load and travel. Athletes participating in elite sports are exposed to high training loads and increasingly saturated competition calendars.

As I have learnt in my approach during these past years, knowledge of muscle-force contributions to hip joint loading may assist in the development of strategies to prevent and manage conditions such as OA, FAI and fracture, by being able to correctly analyse possible mal-adaptations. As discussed in Chapter 3 - Anatomy, four muscles that span the hip – Gluteus

Medius, Gluteus Maximus, iliopsoas, and hamstrings – contribute most significantly to the three components of the hip contact force and hip contact impulse (Correa et al., 2010). Interestingly, they stated that three muscles that do not span the hip – vasti, soleus, and gastrocnemius – also contributed substantially to hip joint loading. The results from their study provide additional insight into lower limb muscle function during walking and may also be relevant to studies of cartilage degeneration and bone remodelling at the hip. This knowledge should be transferred into management with clinical reasoning for sports patients who will be bearing large torsional strain in certain sports e.g. cricket bowlers, baseball, tennis, rugby, football, ice hockey, gymnastics, ballet and other athletes.

Slide 81

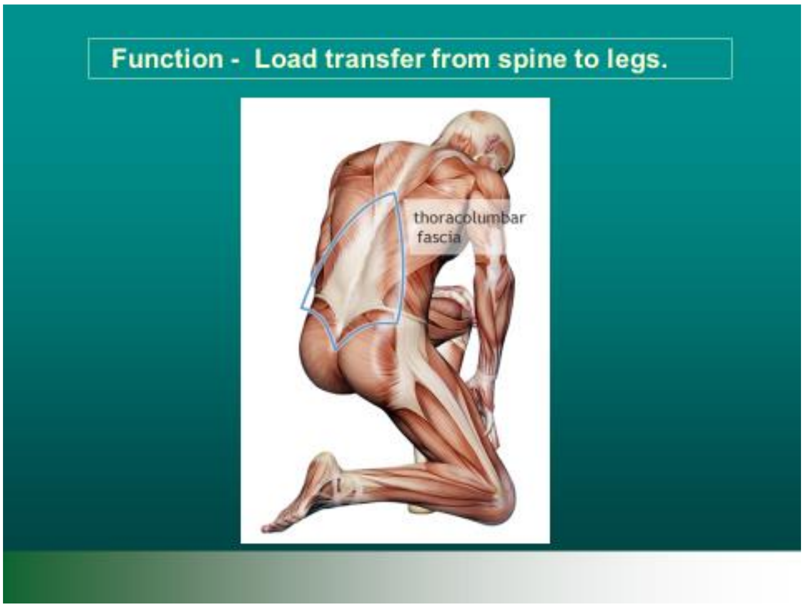


As shown in Slide 81, the bony pelvis functions to transmit forces and weight of the trunk and upper extremities to the lower extremities and to distribute ground reaction forces and to withstand compression forces resulting from its support of body weight. To fulfil these functions, the bony pelvis depends on attachments of powerful muscles and the structural and functional stability of all passive structures around the relevant joints (Meyers et al., 2007). Pelvic assymetry is common among symptomatic and asymptomatic individuals (Hanson, 2002). Pelvic assymmetry is thought to alter body mechanics and affect the length of muscles that originate on the pelvis, resulting in increased strain on bony and soft tissues, possiby resulting in assymetrical adaptions. It is postulated that asymmetry and/or pathomechanics of the pelvic structure can lead to a cascade of compensations throughout the axial spine predisposing individuals to dysfunction and potential injury.

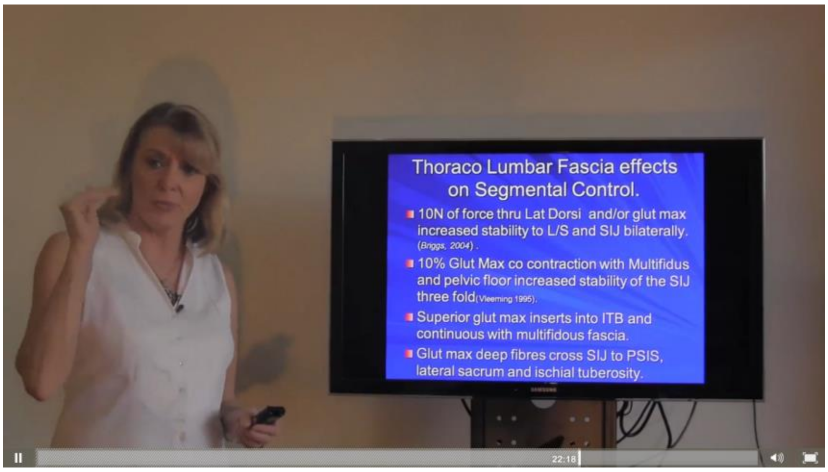
Further, the pelvic girdle is a ring and any change in its anatomy or applied forces to one of the six joints that comprise it, will most likely result in compensation throughout one or more of the six joints. Therefore, a dysfunction on one side of the pelvis is likely to affect the opposite side. An in-depth examination of the functional pelvic girdle from a biomechanical standpoint is necessary to consider how a structure on one side of the pelvic girdle interacts and/or affects the opposite extremity and/or structure.

The need for a thorough understanding of the interconnectedness of the anatomical structures around the groin and hip, including the kinetic chain, has been extensively researched (Vleeming, 1995; Meyers et al., 2005; Robinson et al., 2007; Falvey et al., 2009; Hides et al., 2010; Brandon et al., 2011; Minnich et al., 2011; Meyers, 2012; Brukner and Kahn, 2012; Palisch et al., 2013). The implications for altered biomechanics along the entire kinetic chain due to certain pathologies is thus a significant factor to be considered for management of groin or hip pain.

Slide 82

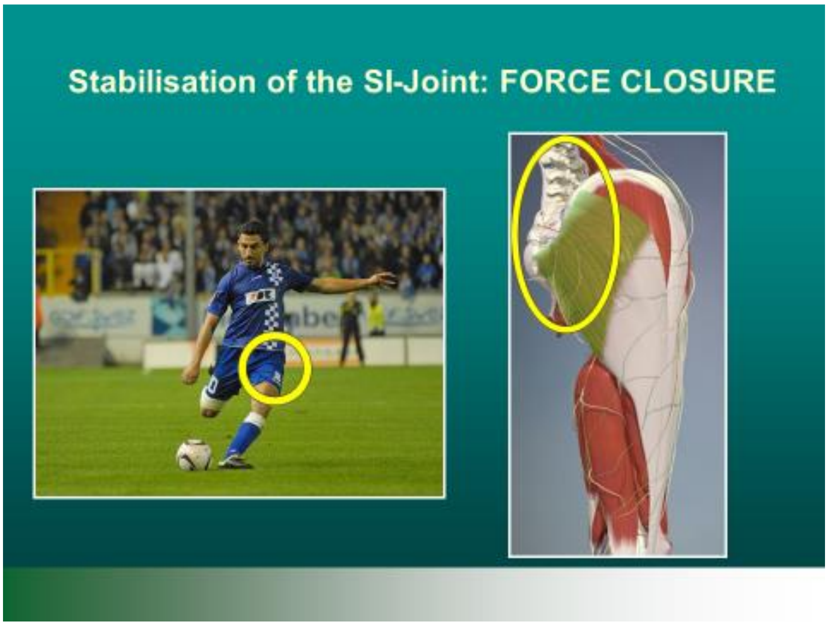


Slide 83



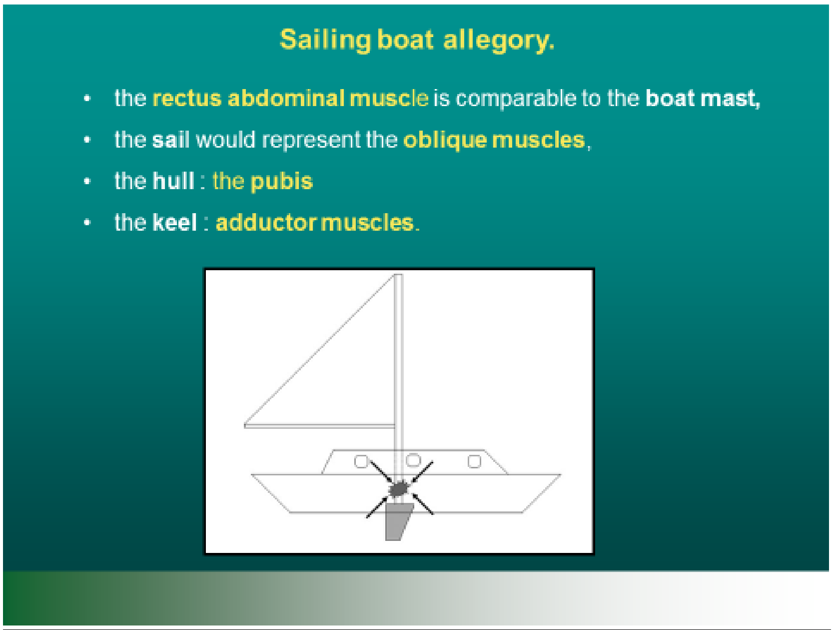
Load transfer has been discussed in the previous section on fascia and functional lines. An example is clearly shown in Slide 82 and also Slide 83, where Trish Wisbey-Roth (2011) discussed the percentage of force and the effect on all the relevant structures. The thoracolumbar fascia is essential for segmental control particularly around the lumbar spine, sacro-iliac joint and the pelvic girdle. It is only these past years that I have taken far better cognisance of the interconnectedness and consequential action of the muscles through the fascia and the resultant forces that are imposed through the pelvis. This increased knowledge has led to me exploring the biomechanical fascia research, as well as suplementing this into my practice. With more insightful assessment and management, I have noticed the resultant positive outcome of any groin and hip problems.

Slide 84

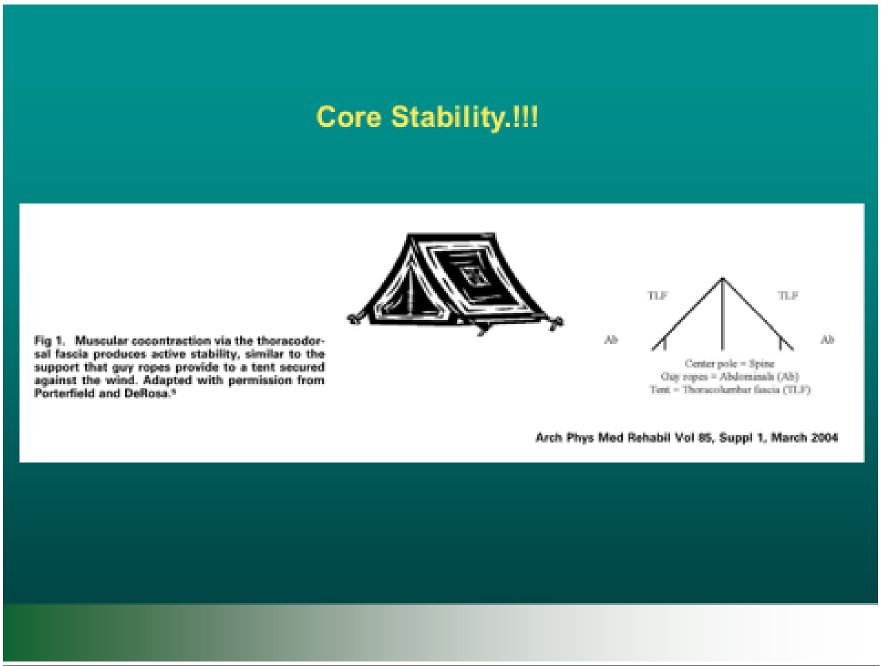


Further, the clinician should take into consideration the relevance of stabilisation of the sacro-iliac joint and the effect that this has on the pelvis (Slide 84). Clinically, I occasionally see the locking of the sacro-iliac joint in athletes with hip problems which one is not always aware of. It is interesting to take note of the causal factor i.e. did the locked sacro-iliac joint joint cause the hip problem in the first place? Thus the need for a comprehensive assessment of all surrounding joints and the entire kinetic chain.

Slide 85

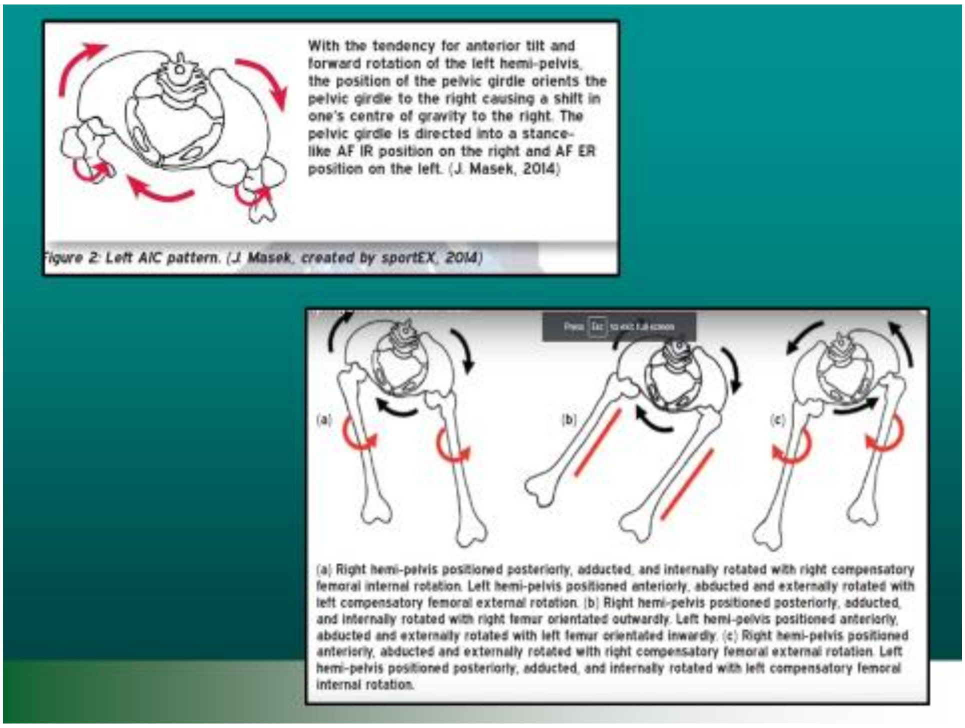


Slide 86



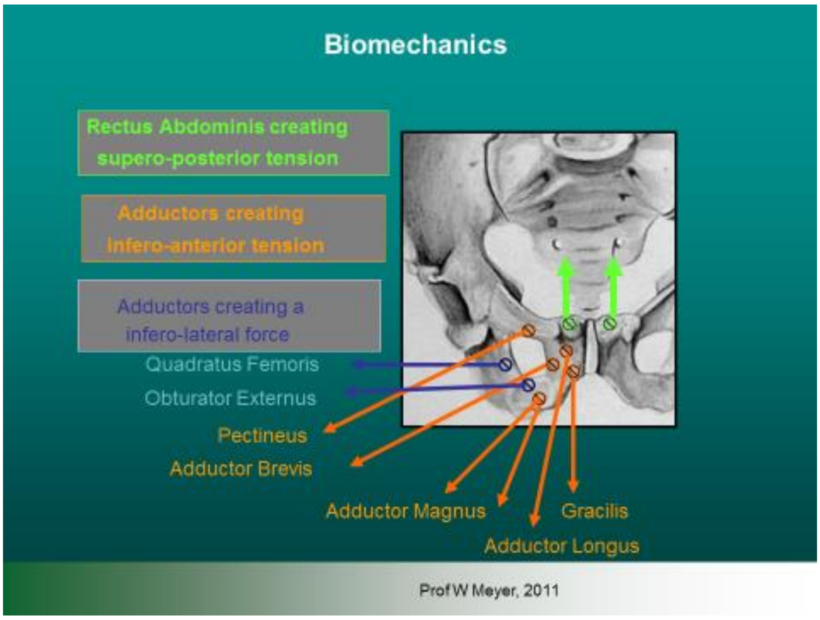
In my clinical presentations, demonstrating the sailing boat allegory (as per the 4 structures working together), as well as the tent theory (guy ropes), I highlight the importance of structures working together to maintain perfect balance (Slides 85 and 86). This allegory shows the value of functionality if all structures work together and I thus focus attention on the interconnectedness of the hip and groin and surrounding structures (Akuthota and Nadler, 2004). Increasingly, I tend to spend longer with my patients, as I am always analysing the entire kinetic chain and never focussing on one specific structure. This requires time and clinicians often cannot afford the time that this procedure demands.

<u>Slide 87</u>

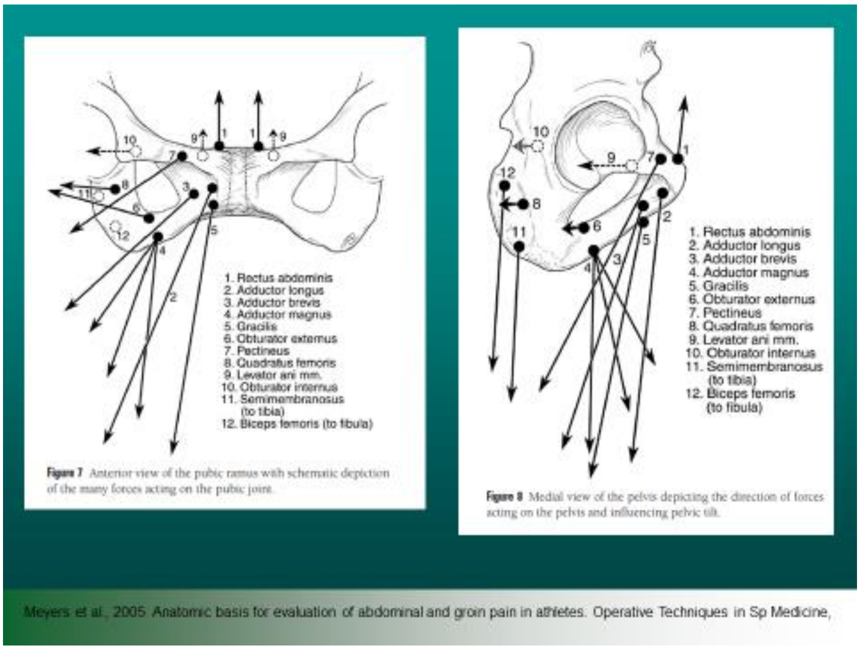


The effect of pelvic movement on the pelvic girdle demonstrates that not only do mal-alignments impose excessive stress on the lumbo-pelvic-femoral complex leading to impingement and possible eventual total hip arthroplasty, but also may have an effect on the rotatory elements of the femur (Masek, 2015) (Slide 87). This may impose on the entire lower extremity. Thus a prevention and rehabilitation programme should focus on restoring acetabular femoral position in all three planes by identifying any malfunctions and correcting accordingly. This would particularly entail pelvic posture correction.

Slide 88



Slide 89

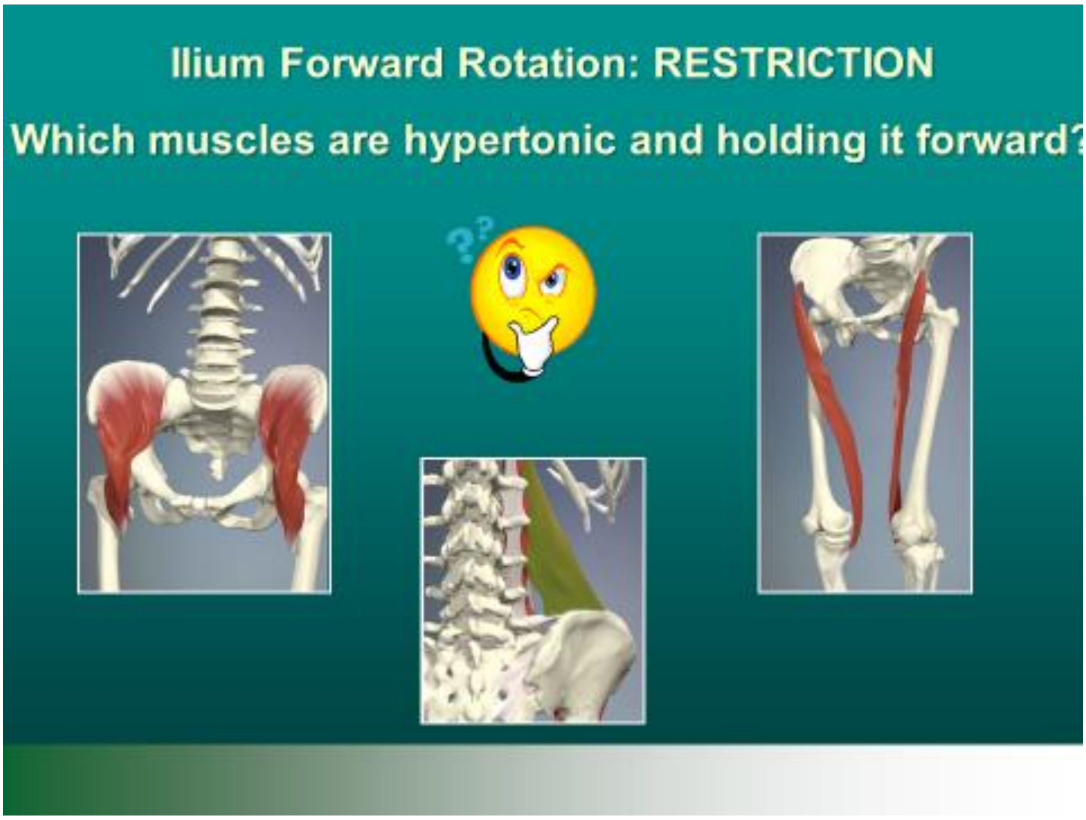


Slide 88 and 89, shows the anterior and medial view of the pelvis and the pubic ramus with the many forces and their direction acting on the pelvis and influencing pelvic tilt. As has been discussed, this has impact on the pelvis, groin area and hips, as well as possible consequences of pathological changes on the lower extremity.

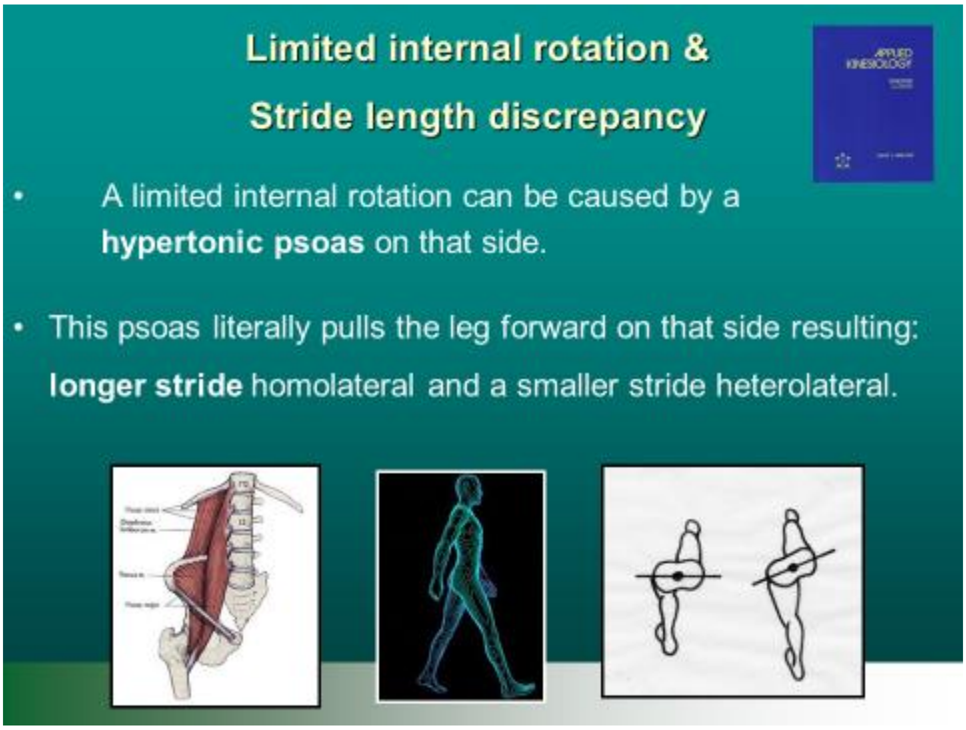
Biomechanics of the muscular forces involved around the pubic joint should be a prime focus when managing sportsmen and women, as the implications of any abnormality is profound

(Meyers, 2005, 2007). Mohammad et al. (2014) explained that the group with “Osteitis Pubis” (pubis symphysis pathology) displayed an increase in hip flexor strength that disturbed the hip flexor/extensor torque ratio around the pubic symphysis. This was also shown in female soccer athletes with hip flexor muscle tightness who exhibit less Gluteus Maximus activation and lower Gluteus Maximus: biceps femoris co-activation (Mills et al., 2015). This imbalance appears to be a risk factor for adductor-related groin injury. Therefore, restoring the correct relationship between these two agonist and antagonist hip muscles may be an important preventative measure that should be a primary concern for training and rehabilitation programmes and this is a strategy that I implement in my management of groin and hip pathologies.

Slide 90



Slide 91



It is most important to analyse which muscles may be the cause of the pelvic rotation and thus possibly develop injuries (Slides 90 and 91). This was highlighted by Prior et al. (2014), where they showed the influence of changes in trunk and pelvic posture during single leg standing on hip and thigh muscle activation in a pain free population. What is significant is that changes in both trunk and pelvic posture during single leg stance strongly influenced the levels of activation of different muscles of the hip and thigh in asymptomatic young males.

Further, dissociation of the pelvis and upper and lower extremities when performing any activities has been highlighted by Comerford and Mottram (2013). They also highlighted the fact that during any unilateral or asymmetrical lower limb movement a rotational force is transmitted to the pelvic and hip region. Clinicians would be advised to study all these specific details to gain more value and insight of the biomechanical interaction of the entire kinetic chain and the importance of dissociation. These uncontrolled movements / movement faults can predispose people to musculoskeletal pain and disability and thus this identification may be a prevention strategy for hip pain. This is crucial in my management of groin and hips.

Slide 92

Further abnormal forces around the pelvis were concisely identified by James Allen (Football Medical Association Conference, Midlands, United Kingdom, 2016) and shows the unusual biomechanical loads imposed on the body in different actions in rugby (Slide 92).

4a iii. Walking

Lewis et al. (2007) described a musculoskeletal model which indicated that increasing the maximum end range hip extension when walking results in an increase in the anterior hip joint force when compared to walking in less hip extension which may contribute to anterior hip pain. They recommended that further studies were warranted to determine if increased activation of the gluteal muscles during hip extension and of the iliopsoas muscle during hip flexion, and possibly the avoidance of hip extension beyond neutral would be beneficial for people with anterior hip pain, subtle hip instability, or an anterior acetabular labral tear. An understanding of these walking biomechanics may assist clinicians to implement a strategy for gait modification to reduce anterior hip force when patients present with anterior hip pain. Clinically, although there is no evidence for this strategy, I have found that runners who have anterior or lateral hip pain experience decreased pain when taking shorter strides. However, this modification may be detrimental to performance, so the long-term use of this modification may not be advised. Studies to verify this observation would be most helpful.

Correa et al. (2010) analysed the contributions of individual muscles to hip joint contact force in normal walking. Four muscles that span the hip – Gluteus Medius, Gluteus Maximus, Ilio-Psoas and Hamstrings, contributed most significantly to the three components of the hip contact force and hip contact impulse. Additionally, three muscles that do not span the hip – Vastus Lateralis, Intermedius and Medialis, Soleus, and Gastrocnemius also contributed substantially to hip joint loading. Even though the major limitation of this study was that it pertains only to walking of healthy young adults, the results provide additional insight into lower limb muscle function during walking and may be relevant to studies of cartilage degeneration and bone remodelling at the hip. This knowledge should be transferred into management with clinical reasoning for sports patients who will be bearing large torsional strain in certain sports e.g. cricket bowlers, baseball, tennis, rugby, football, ice hockey, gymnastics and ballet.

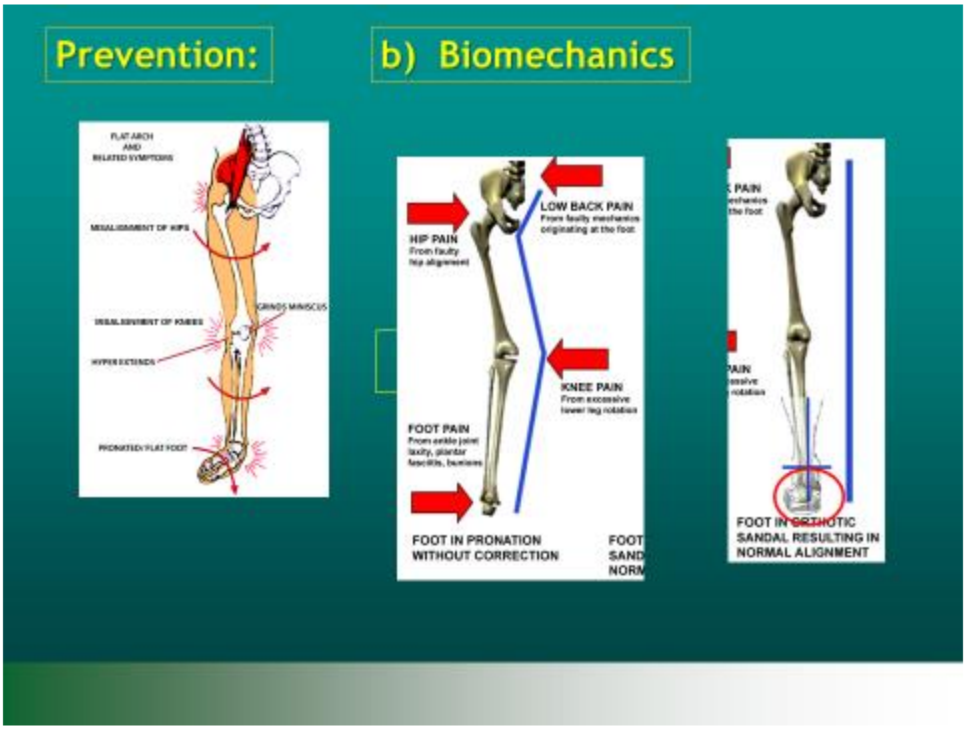
The significance of the Gluteus Maximus related to its importance in the entire movement of the human kinetic chain, was described in the previous chapter. Gluteus Maximus is mostly quiescent during walking and running, with low levels of activity during level and uphill walking, but increases activity as speed increases during running (Liebermann et al., 2006). In an attempt to understand the relationship between walking gait speed and hip joint loading in healthy hips, Weinhandl et al. (2017) undertook a study with healthy individuals and found that there were significant increases in vertical ground reaction forces and hip joint forces as walking speed increased.

Thus regarding biomechanics, the implication of biomechanics and load in all aspects of life and sporting action requires in-depth observation and knowledge.

4b. Pathologies related to Hips and Biomechanics

Clinicians have acknowledged that abnormal foot mechanics e.g. pes planus/pes cavus and consequential knee malalignments e.g. genu varus /valgus, may have an effect along the entire kinetic chain, including the hip and groin region.

Slide 93



This is shown on Slide 93 where prevention of these pathologies are highlighted as a possibility.

Table 3 - Pathologies related to hip and lower extremity kinetics.

Author	Outcome
Bandholm et al. (2011).	Explained the **importance of the relationship between hip muscle strength and neurological control which has profound effect on the lower extremity muscles.**
Takacs and Hunt, (2012).	**Pelvic drop** as a result of **hip abductor weakness** has been hypothesized as a potential modifier of frontal plane knee joint kinetics during gait in individuals with pathology such as **knee OA.**
Stearns and Powers, (2014).	The study results suggest that **ACL injury prevention programs targeting hip muscle** performance may be important in mitigating biomechanical risk factors associated with **ACL injury** in women.
Bencke et al. (2014).	**Increased hip internal rotation and increased hip abduction** appeared to negatively influence the magnitude of knee valgus moment during side cutting, and thus potentially increase the risk of **ACL Injury.**
Mohammad et al. (2014).	**Isokinetic imbalance of hip muscles in soccer players with osteitis pubis.**
Hetsroni et al. (2015).	**FAIS** is associated with alterations in **hind foot mechanics**
Lin et al. (2015).	**Quickening and widening steps probably increase stability.** Shorter affected side stance time to avoid pain, and/or weakened affected side hip abductors, may lead to faster frontal plane trunk movements toward the unaffected side, which could **contribute to fall risk.**

Resende et al. (2015).	**Increased foot pronation** increased the ipsilateral lower limb internal rotation angles and **reduced knee and hip internal rotation moments with increased pelvic ipsilateral drop.** Foot pronation increases hip and knee adduction moments on the contralateral side.
Hagen et al. (2015).	Semi-professional soccer players with **increased hip alpha angles** showed **differences in gait kinematics** compared to the amateur group.
Solomonow-Avnon et al. (2015).	Footwear-generated biomechanical manipulation e.g. wedge insoles and foot orthotics of lower-limb joints has been shown to influence lower-limb biomechanics. This study analysed **kinetic and kinematic changes about the hip** of 12 healthy young males who underwent biomechanical manipulation utilizing a biomechanical device allowing controlled foot centre of pressure manipulation. It demonstrated the **reduction of frontal-plane hip joint reaction force via medial-lateral foot centre of pressure manipulation and the subjects adopted a modified gait pattern** aimed to maintain constant base of support. **As a result, hip abductor muscle moment arm increases and adduction moment and joint reaction force decreases**
Khayambashi et al. (2015).	**Measures of preseason isometric hip abduction and external rotation strength** independently predicted future noncontact **ACL injury** status in competitive athletes. The study data suggest that **screening procedures to assess ACL injury risk should include an assessment of isometric hip abduction and/or external rotation strength**.
Sakaguchi et al. (2015).	**Hip external rotation angle may be a key factor to control frontal plane knee joint kinematics and kinetics**. Thus the position of the hip joint should be taken into consideration when assessing a patient with lower extremity problems. They hypothesised that their results may help provide an appropriate intervention on running style to **reduce the risk of PFP.**
Hetsroni et al. (2015).	**Young adult men with Cam-type FAIS present excessively inverted hind-foot at the moment of heel strike and reduction in maximum eversion during the stance phase.**
Deasy et al. (2016).	**Significant hip strength deficits** exist in people with **knee osteoarthritis.** Hip strength assessment should be considered in clinical practice and may assist with directing targeted management strategies
Van den Berg et al. (2017).	**Restricted hip rotation is correlated with an increased risk for ACL.**
Boykin, R. E. (2018).	Patients with radiographic evidence of FAI and decreased hip internal rotation have a higher rate of ACL tears**. Limited internal rotation of the hip increases strain and potentially resultant fatigue failure of the ACL**
Rutherford et al. (2018).	The implications of **individuals with FAIS** compared with healthy, asymptomatic individuals were shown to **affect hip joint biomechanics and muscle activation.**
King et al. (2018).	These findings demonstrate that **subtle biomechanical impairments may be present in individuals with hip-related groin pain,** despite there being no difference in morphology or hip strength.
Neamatallah et al. (2020)	**Hip and knee kinetic and kinematic variables related to the development of dynamic knee valgus would appear to be influenced by gluteal muscle strength**. The level of influence varies across SLS and landing tasks and would appear superficially to differ between genders. **A gender specific strength training programmes Is required to reduce dynamic knee valgus**.

Cam: Camshaft, (which the shape of the femoral head and neck); OA: Osteo Arthritis;

PFP: Patella Femoral Pain; ACL: Anterior Cruciate Ligament;

FAIS: Femoro-Acetabular Impingement Syndrome; SLS: Single Leg Squat.

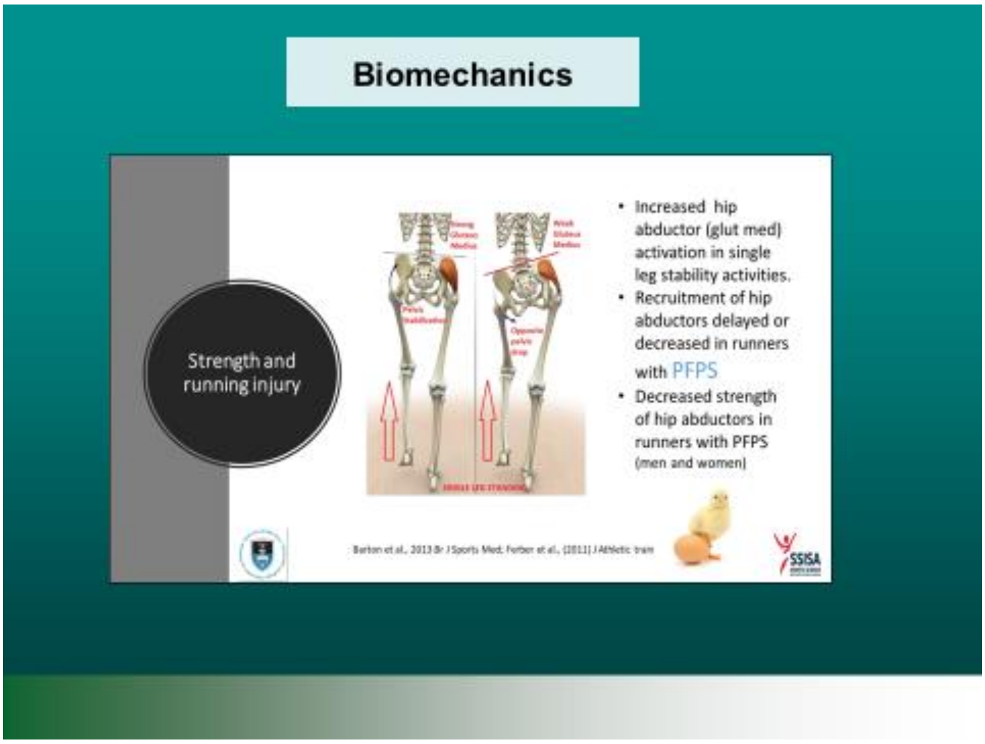
Further studies have highlighted this interaction between the pelvis and lower extremity and possible pathological consequences if biomechanically inefficient:

- **Patella- Femoral Pain:** the link between the trunk, pelvis, hip (including hip strength and gluteal muscle activation), and knee kinematics. (Cowan et al., 2009; Esculier et al., 2015; Ferber et al., 2011; Nakagawa et al., 2012; Pairot de Fontenay et al., 2018; Plastaras et al., 2016; Reiman et al., 2009; Thomson et al., 2016; Van Cant, 2014).

- **Lumbar/Sacral spine pathologies**: the link between hip impairments, (including hip joint range of motion and gluteal activation) and low back pain. (Cooper et al., 2016; Hanson et al., 2002; Janda and Jull, 1987; Mendis and Hides, 2016; Pool-Goudzwaard et al., 1998; Reiman et al., 2012).

Groin pain is based on a complex framework dependent on numerous factors linked together by a complex cause / effect relationship (Bisciotti et al., 2015; Kloskowska et al., 2016). As shown in Table 3, many pathologies may be affected by malfunction of the pelvic, hip and/ or lower extremity biomechanics.

<u>Slide 94</u>

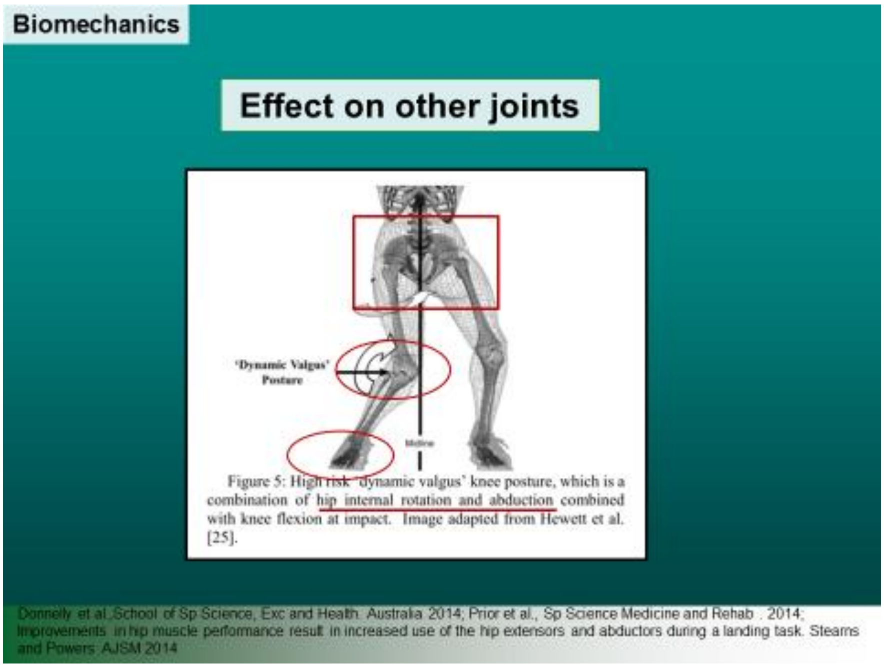


There is growing evidence to support the association of gluteal muscle strength deficits in individuals with patellofemoral pain syndrome and the effectiveness of gluteal strengthening when treating patellofemoral pain syndrome. Additional research is needed to determine if screening of gluteal muscle activity can successfully identify those most likely to develop patellofemoral pain syndrome (Barton et al., 2013) (Slide 94).

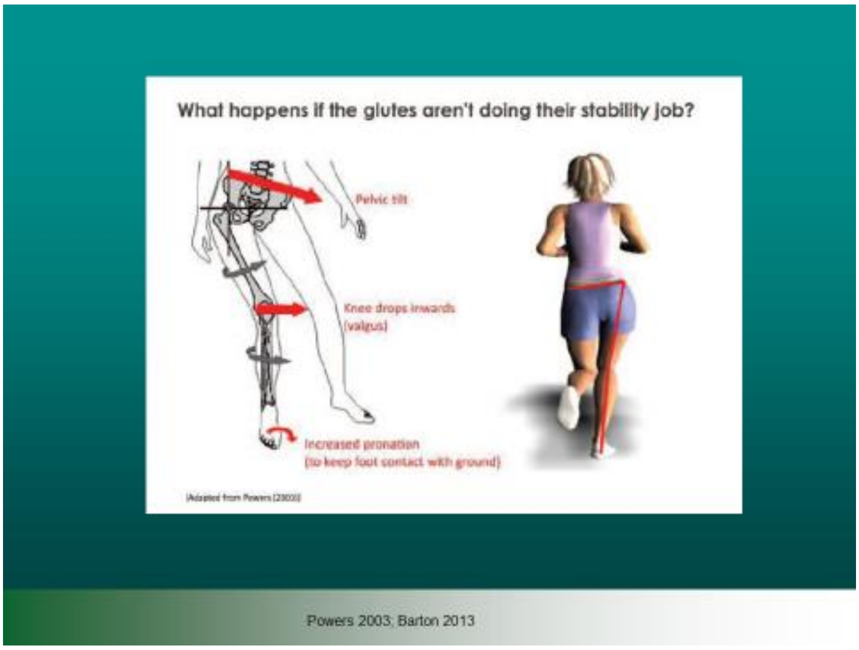
Overall, the studies, as above, demonstrate how hip biomechanics can impact knee pathologies, as well as foot and knee mechanics which may cause hip pathology. The take home message is that the entire kinetic chain needs assessment, whether as a prevention protocol or for rehabilitation of any hip/lower extremity joint.

Recently, with my work at Groote Schuur Hospital with young sports injury adolescents, the majority who have had an ACL / meniscal repair, it has been most interesting to observe that most of them have weak hip stabilisers (Gluteus Medius / Gluteus Minimus). This is not necessarily the cause of the injury in the first place. However, I believe the clinician should take cognisance of this fact, as this weakness may cause knee valgus (and thus susceptibility to knee pathology) and might lead to a recurrence of the injury. Thus this should be a basic strategy for prevention and management. In my clinical experience, my observation is that clinicians (including myself), have not always prioritised the importance of the hip stabilisers sufficiently when assessing the athlete for other pathologies.

Slide 95



Slide 96

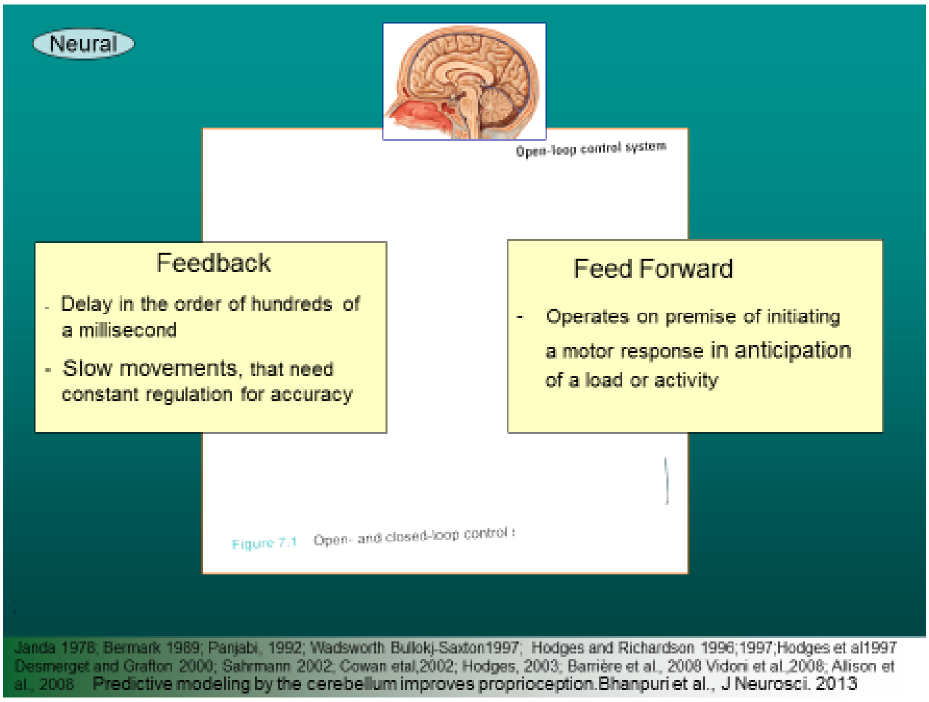


This interconnectedness is demonstrated in Slides 95 and 96 showing that if the Gluteii muscles (particularly Gluteus Medius and Minimus) are not performing adequately and there is subsequently hip internal rotation and abduction this may have implications on the knee and foot (Barton et al., 2013). Specific tests such as the Trendelenburg Test to identify these problems will be discussed in Chapter 5 on Tests.

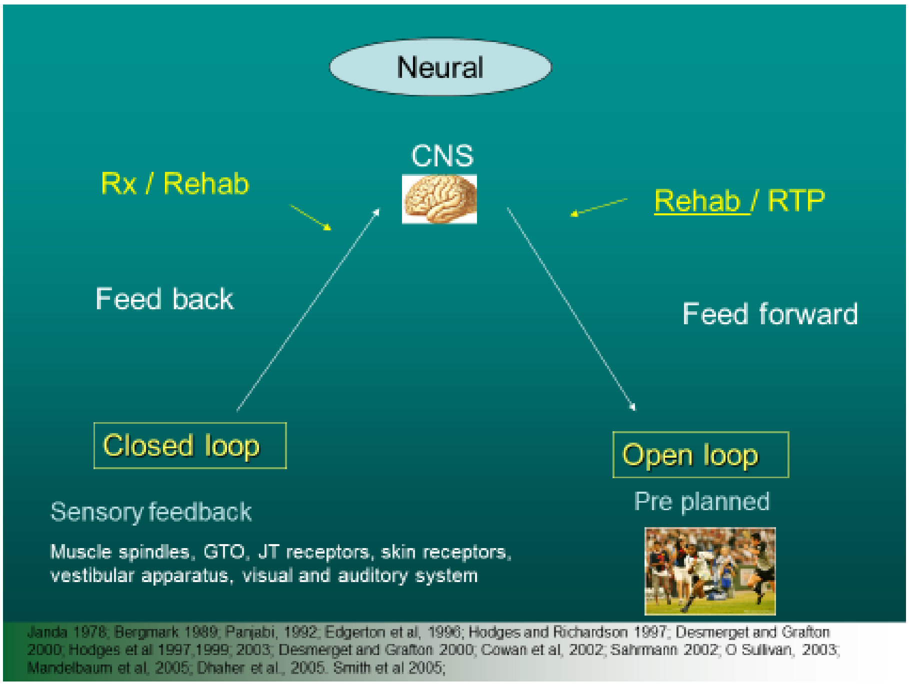
Regarding pathology and hip damage, the relevance of abnormal movement at the hip and the possible consequence of acetabular labral pathology and even eventual OA should be considered (Austin et al., 2008).

4c. Neuromotor control

Slide 97



Slide 98



Slide 99

The biomechanics of human movement is most relevant in all sports domain and relies on optimal neuromuscular control (Slides 97, 98, 99). The recognition of the significance of correct neuromuscular training for prevention and rehabilitation of injuries is essential for appropriate management of groin and hips. At the Football Medical Conference (Midlands, United Kingdom, 2016), Wright gave his opinion that clinicians often focus on improving strength of isolated muscle groups and not enough consideration is given to the neuromuscular control of the whole kinetic chain and hence the functionality of the muscles in the entire kinetic chain. I concur with this comment, as I believe that neuromuscular control is the basis and foundation for all movement and thus have given many workshops / presentations on this much under-appreciated basis of management. In my curriculum for Physiotherapy many years ago, neuro-muscular training was the highlighted aspect of our curriculum. In the past years this has not been the case, hence my passion for this implementation as the root of all treatment, as perceived by my excellent outcomes. Sharing this aspect i.e. neuromuscular training and proprioceptive neuromusclular facilitation, with all my colleagues around the world, consisting of a day's presentation and workshop, is most worthwhile and rewarding.

Studies showing the impact of postural control and hip stability, as well as degenerative diseases of the hip joint include those of Allen, (2016); Mendis and Hides, (2016); Narveson et al. (2016);

Roden-Reynolds et al. (2015); Sziver et al. (2016) and Torry et al. (2006). The basic discussion around these studies imply that motor control training of all biomechanical movements in each individual sport is imperative for full functionality in any sporting activity. This is regardless if there is a symptomatic pathology such as Femoro-Acetabular Impingement Syndrome (FAIS), or is merely for a preventative strategy for any potential groin / hip problems.

Regarding biomechanical assessment and screening to prevent injuries, this will be covered more comprehensively in Chapter 11 - Prevention. As tests and exercises become more functional, overlapping questions arise as to where the weak link is in chain and where the transfer of load will be liable to failure.

4d. Different sports and specific biomechanics

Different sports (and positions within the sports) have specific demands which call for various activation patterns and contributions of particular muscles. As a clinician, it is useful to have a thorough understanding of the mechanics of each sport, as well as the individual positions in the sport. These provide a baseline for assessment and management as it is acknowledged that there is significant variation in biomechanics between sports, positions and individuals. Whilst with the Super 14 Rugby team (for 5 years) 7 days a week, it was a perfect environment for me to analyse every positon and movement within the game (plus all the varying factors) by assessing individual positions whilst they were training and even occasionally participating. An example was being lifted and lowered as the lock to experience the nuances of this positon and the consequential possibility of back pathologies. I believe this assisted me in preventing pathologies due to my advice regarding a more careful approach to this movement, particularly being very careful not to suddenly let go of the lock after lifting him up high to retrieve the rugby ball. I have shared this aspect with my colleagues in my presentations and have specified the need to intensely analyse the exact movement required by an athlete and addressing it accordingly.

4di. Running

The different contributions of the hip muscles to the task of running are not well understood, and it may be important for recognizing the biomechanical mechanisms of running-related injuries and refining current treatment and prevention strategies, particularly for groin and hip problems.

Cognisance should be taken of the many studies discussing running biomechanics and the correct sequence of movement (Napier et al., 2015 and Snyder et al., 2009). Of interest is the study by Schache et al. (2000) who explored the implications of limited hip extension flexibility due to tight hip flexor musculature or anterior hip capsular and ligamentous structures and their possible cause of increased anterior tilt of the pelvis during running, bearing in mind that the anterior pelvic tilt and hip extension are coordinated movements during running.

Another important factor is the role of Gluteus Maximus in running. The major functions of the Gluteus Maximus during running is to control flexion of the trunk on the stance-side and to decelerate the swing leg. Contractions of the stance-side Gluteus Maximus may also help to control flexion of the hip and to extend the thigh (Lieberman et al., 2006). All this may be affected by incorrect biomechanics.

Further, the consideration of weak hip muscles is of value in development of running-related injuries (Niemuth et al., 2005). Although no cause-and-effect relationship was established, their study showed an association between hip abductor, adductor, and flexor muscle group strength imbalance and lower extremity overuse injuries in runners. The addition of strengthening exercises for weak hip muscles may offer better treatment results in patients with running injuries. This should be adapted by clinicians working with any groin or hip pathologies (or for prevention).

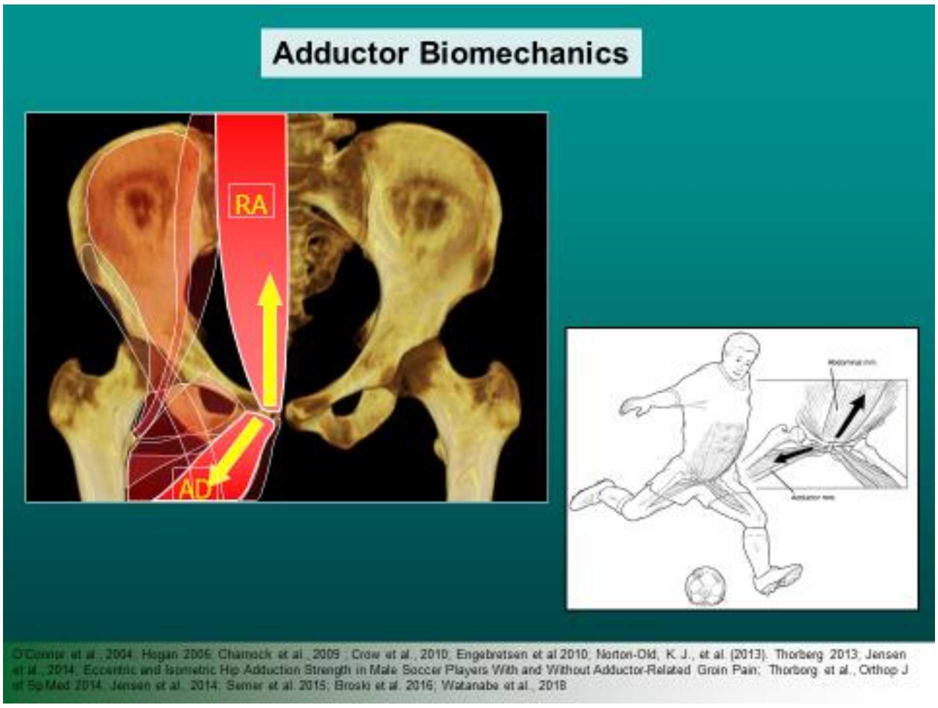
Another pertinent fact that should be taken into consideration when designing management strategies for athletes regarding hip and groin problems, is that of the gender differences and biomechanical implications. The biomechanical factors of the hip between sexes were investigated with regard to running-related injury (Vannatta and Kernozek, 2018) and their outcome showed that males and females demonstrate differences in gluteal muscle forces and hip kinetics and kinematics during running. Females may have to generate greater gluteal medius and minimus muscle forces to meet the requirements imposed partially by greater hip adduction position of the hip. Females may also utilise a different muscular strategy to generate hip extension and external rotation moment than males. Clinicians need to be aware of these differences when assessing or managing these athletes and bear it in mind with all biomechanical assessments in all sports.

4dii. Cycling

I have given a number of presentations over the years regarding prevention and management of cycling injuries e.g. Cyclists Touring Club, Suffolk and Team Sky. Apart from a number of studies over the years on cycling biomechanics, there is minimal evidence that specifies the impact of cycling on the pelvic/hip region and the possible resultant pathologies that may develop (Burnett et al., 2004; Damm et al., 2017; Hull et al., 1990; Juker et al., 1998; Muyor and Zabala., 2016; Navot and Kalichman, 2016; Sauer et al., 2007; Trofaier et al., 2016). Although some may study hip movement, they do not specify specific hip muscles involved e.g. Elmer et al. (2011). The findings by Ando et al. (2019) indicated that the relative contribution of the Gluteus Maximus and Rectus Femoris to the cycling movement can be enhanced using a high intensity protocol. It would be useful to obtain more information of exact muscle input at different phases of cycling.

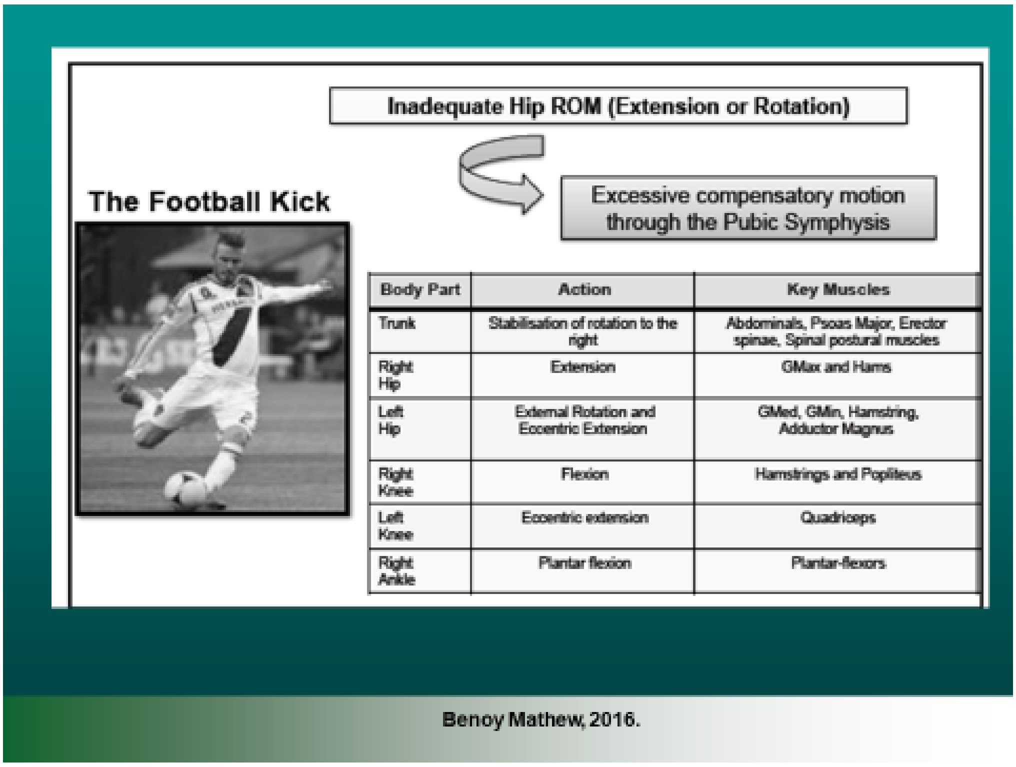
4diii. Football

Slide 100



The kicking action in football was claimed to be the most frequent reported football action inciting groin injury (Langhout et al., 2018) and has been increasingly documented in studies (Jensen et al., 2014; Rada et al., 2019; Torreblanca-Martinez et al., 2017; Watanabe et al., 2018) (Slide 100). Charnock et al. (2009) highlighted the role of Adductor Longus during the kicking and swing phase and the risk of injury of this muscles during the transition from hip extension to hip flexion.

<u>Slide 101</u>



Interesting for clinicians is the in-depth analyses of the football kick, where inadequate hip range of motion causes excessive compensatory motion through the pubic symphysis and possible resultant effects to the kicking muscles involved (Slide 101). Langhout et al. (2018) explained that the central body actions play an important role in kicking and maximal kicking showed larger segmental range of motion than submaximal kicking. Thus football players with groin injury refrain from maximal kicking. I have considered this factor and my approach for prevention and rehabilitation has improved these past years with this knowledge, as has been the case with many sports clinicians who keep up with the latest research on this topic. Previous groin injury was related to decreased hip range of motion and they stated that information on range of motion differences between maximal and submaximal kicking within players is lacking. A finding explaining detailed kicking action, demonstrated the coordination of body segments during the maximal kick in (sub) elite football players. Range of motion of the backswing is important to allow pre-stretch of myofascial structures and range of motion of the forward swing is mandatory to develop segmental velocity. These findings suggest that flexibility of the tension arc and pelvis are essential in developing ball speed. All the above points are significant when clinicians are tailoring a rehabilitation or prevention protocol.

Further studies explaining the intricacies of change of direction in soccer include Malloy et al. (2016) and Rouissi et al. (2016). Malloy described the outcome that females with greater hip external rotator strength demonstrated better dynamic control of the lower extremity during unanticipated single-leg landing and cutting tasks and provides further support for the link between hip strength and lower extremity landing mechanics. These factors should be analysed when assessing any groin or hip pathologies.

Wright at the Football Medical Conference (Midlands, United Kingdom, 2016), discussed a study which demonstrated the altered patterns of landing, cutting and change of direction in footballers who present with groin pain (Botha et al., 2014). These preliminary findings suggested that impaired movement control exists in academy footballers with FAIS. These biomechanical mechanisms of dysfunction, where there is dissociation of the femur and the trunk may cause lumbo-pelvic hip instability and identifying and classifying these movement faults may prove necessary for effective prevention and management of symptoms by controlling movement adaptations.

King et al. (2018) found that soccer players with unilateral hip-related groin pain may exhibit distinct biomechanical differences compared with the asymptomatic side. This was re-affirmed by Rutherford et al. (2018). However, they expressed their opinion that there is a lack of objective testing of hip joint function to understand implications of FAI for dynamic movements, particularly with applications to biomechanics. These permutations will be referred to in the rehabilitation chapter.

4d iv. Ice Hockey

Although I have not been personally involved in ice hockey, I have endeavoured to understand the unique functional demands and the patterns of injuries they may promote.
Certain movements often place the hip in forced and repetitive supra-physiological ranges of motion (Brunner et al., 2016). Kallio et al. (2015) explained that hip problems have increased, especially among young ice hockey goalkeepers and those using the butterfly technique. Thus these athletes commonly endure groin injuries or hip pain (Kuhn et al., 2016). Mosenthal et al.

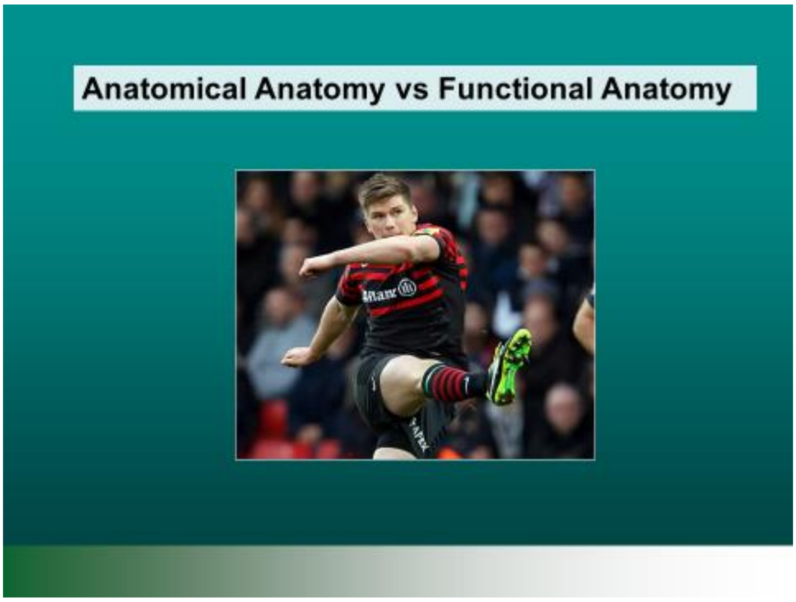
(2017), explained that activities such as powerful forward or cross-over skating requires strong eccentric contraction of the adductors, making this muscle group particularly vulnerable and thus may lead to common groin pain experienced by these players.

Summary - Functional Anatomy – Biomechanics

The biomechanics of all movement, which includes the normal range of variability between individual athletes, as well as the biomechanics of specific sports, requires an in-depth understanding and analysis. This includes basic posture to load management through the entire kinetic chain with knowledge of the interaction of all muscles, joints, fascia and tendons. The comprehension of the possible other pathologies associated with the groin and hip biomechanics, as well as any mal-adaptations, requires assessment with all athletes and on an individual basis.

Conclusion – Anatomy versus Functional Anatomy

Slide 102



As I have observed in my career, the complex and intricate anatomical relationship and functionality required is frequently underestimated when dealing with hip and groin pathology in elite and recreational sportsmen and women. I, personally, have definitely improved my management of hip and groin athletes since I have undertaken this thesis and absorbed so much new information. I have also had very positive responses from my fellow colleagues when giving presentations, as they too have previously not recognised this vital factor and realise now that a thorough understanding of the basic underlying anatomy, pathophysiology and biomechanics of individual athletes, may lead to considerable advances in their care (Slide 102). The challenge lies between ascertaining the anatomical diagnosis vs. pathological diagnosis vs. functional diagnosis. The interaction of the three will influence prognosis and management.

Thus by understanding all these permutations and having an in-depth knowledge of the entire structural and functional anatomy involved, a screening programme can be developed and prevention programmes put in place. This thesis is being undertaken to underpin this understanding and to share this knowledge with clinicians in relevant sport domains so that they can use it constructively to advise management and preventative strategies for athletes with, or at risk of groin and hip pathologies.

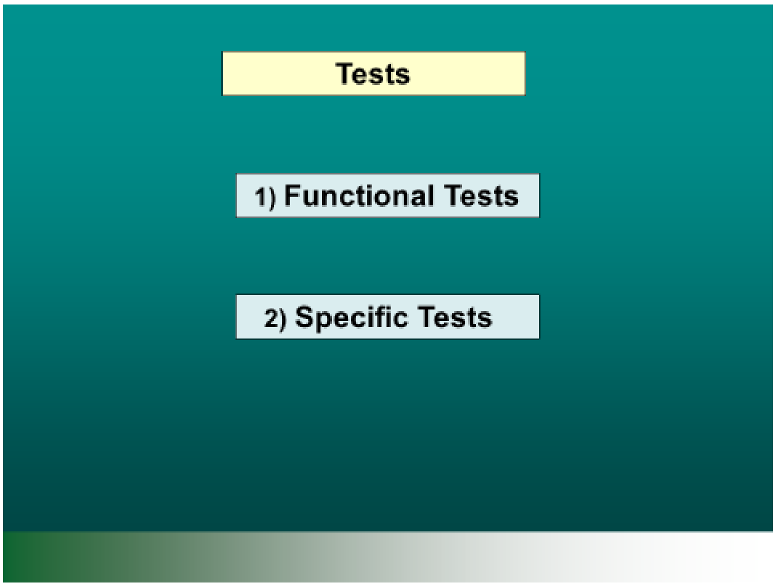
Chapter 5

Groin and Hip Assessment

5a. Introduction

As discussed in previous chapters, hip and groin pain can be a long-standing and debilitating condition. The complex clinical presentation and multiple symptoms related to groin pain often impede sports clinician's ability to establish its severity and provide specific guidelines for optimal management. Several tests have been suggested as screening and assessment tools for evaluating a prevention strategy, specific treatment and readiness to return to play. However, the clinical tests available to diagnostic clinicians are complex due to the non-specificity of each test. This may be one of the reasons that patients with groin and hip problems frequently have a delayed specific diagnosis and may undergo inappropriate management. I agree with the study by Reiman and Manske (2012), whereby they explained that the decline in the performance of a skilled clinical examination has possibly occurred from an over reliance on clinical special tests, laboratory tests, and imaging. All these factors have mostly been lacking in general consensus on the specificity of the outcomes. Fortunately, studies have been evolving over these past years with better specificity and sensitivity for testing groin and hips (Reiman et al., 2015). The specificity and sensitivity of these individual tests are detailed in Chapter 5e. As a clinician, I have used the literature to identify tests which have been found to be effective both scientifically and clinically. It would be of great benefit if one could identify athletes at risk for developing groin injury by the use of specific tests (Delahunt et al., 2016).

Slide 103



This chapter endeavours to highlight tests that have been most useful in my practice if used and analysed correctly (Slide 103). Functional tests, in particular, have been helpful and applicable. Specific tests are useful if they are part of a battery of tests, especially for tests with low specificity and sensitivity, and also analysed with sound clinical reasoning.
Thus it is most important that functional tests as well as specific tests are performed on the athlete with groin and hip pain (and in pre-screening). Functional performance testing examines the ability of the person to put together a series of movements, rather than isolated single joint and planar movements, to safely and efficiently complete a task.

From my clinical practice, I have found that the diagnosis is not always possible from the specific tests (bearing in mind the multiple pathologies which might be involved with the groin / hip pain). The functional tests show certain mal-adaptations /deficiencies. If these are rectified in a management strategy, the athlete can be successfully rehabilitated without a specific diagnosis. This is a key point of my thesis. In the absence of evidence surrounding a number of these functional tests, sound and consistent use of clinical reasoning remains essential to any clinician. Clinical reasoning is the process by which a clinician interacts with a patient, collecting information, generating and testing hypotheses, and determining optimal diagnosis and treatment based on the information obtained. This management requires ongoing assessment and re-assessment throughout the season.

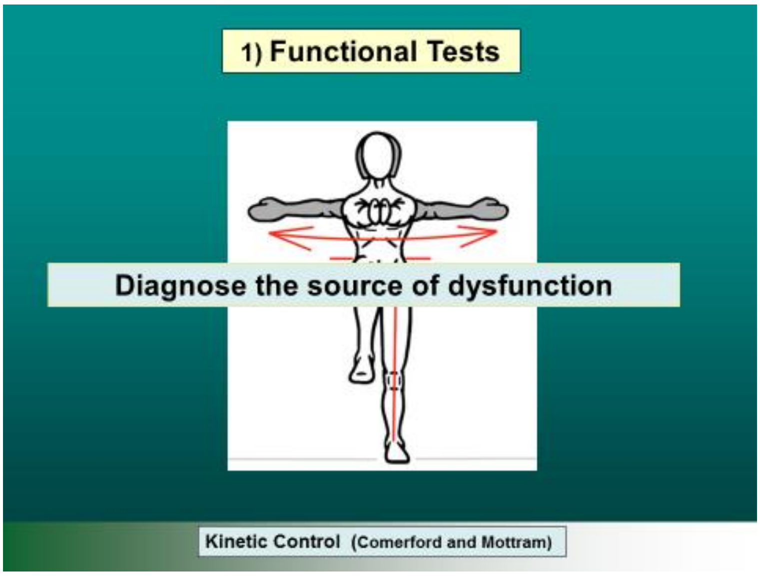
5b. Functional Tests

5b i. Background

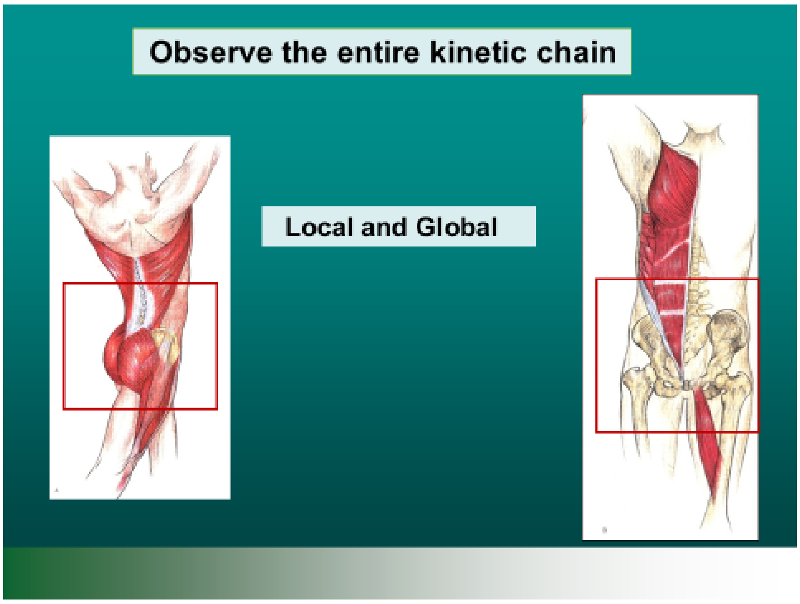
Sports-related groin pain is a common entity in rotational sports such as football, rugby and hockey, accounting for 12-18 % of injuries each year, with high recurrence rates and often prolonged time away from sport (Kloskowska et al., 2016). Thus, as has previously been mentioned, the precise movement patterns and associated muscle function in athletes both prior to and following the onset of sports-related groin pain need to be scrutinized.

Functional tests are my most useful tool and the cornerstone for assessing and managing an athlete with groin and/or hip pain (Reiman and Manske, 2011; Reiman and Manske 2012). A clear distinction should be made between clinical testing and functional performance testing. Functional performance testing has multiple purposes. It can provide quantitative and qualitative information on specialized movements in sport, whereas clinical testing is at the level of impairment, not the assessment of overall functional ability (Manske and Reiman, 2013). They claimed that functional performance tests can help determine when an athlete can return to unrestricted activity, although further research is desperately needed in this area to determine how adaptations during functional tests can be measured and quantified. Additionally, a lack of standardization exists, as little information is known about how various tests relate to one another and which tests are best to use in isolation or in combination as a means to assess a broad range of function. They concluded that it is highly likely that performance-based function testing should utilize a wide range of assessments, including patient self-report questionnaires, assessment of psychological factors (e.g. fear), and quality of movement during functional tests as assessment for return to function.

Slide 104



Slide 105



Central to functional testing is identifying the source of dysfunction (Slide 104). This can only be done by observing the entire kinetic chain and performing a series of functional tests accordingly (Lewis and Sahrmann, 2015) (Slide 105).

Regarding functional tests, as has been discussed in Chapter 4 - Functional Anatomy, strengthening hip abductor muscles has been a recent effective trend in therapeutic intervention studies to prevent and rehabilitate different pathologies such as low back pain this should be done for all our sports patients, as the hip abductor muscles are crucial for the correct functioning of the entire lower extremity.

Table 4: Functional Tests

Title	Author	Test	Outcome
The relationship between hip-abd strength (HABD) and the magnitude of pelvic drop in patients with LBP.	Kendall et al., 2010.	Trendelenburg test (TT)	HABD strength **may not be the only contributing factor in controlling pelvic stability**, and the **static TT has limited use** as a measure of HABD function
Increased external hip-rotation strength relates to reduced dynamic knee control in females: Paradox or adaptation?	Bandholm et al., 2011.	Drop Jumping	**Greater maximal external hip-rotation torque was related to greater change in knee marker** distance during drop jumping
Glut muscle activity and PFP: A systematic review.	Barton et al., 2013.	Stair ascent and descent	The relationship between the gluteal muscles and PFP showed moderate-to-strong evidence that **G Med muscle activity is delayed and of shorter duration** during stair ascent and descent in individuals with PFPS. There was impaired ability to control frontal and transverse plane hip motion.
Greater understanding of normal hip physical function may guide clinicians in providing targeted rehabilitation programmes	Kemp et al., 2013.		**Provided clinicians with a number of reliable, clinically applicable tests.** Strength measures and functional performance measures explained as a reference for assessment
The recognition and evaluation of patterns of compensatory injury in patients with mechanical hip pain.	Hammoud et al., 2014.		**A "layered approach" to understanding the aetiological factors contributing to pain** around the hip joint and associated hemi-pelvis,
The pelvic femoral rhythm in cam-type FAI.	Van Houcke et al., 2014.		Posterior pelvic rotation during active high-end hip flexion is increased in FAI, indicating the presence of **an active compensational mechanism**
The relationship between maximal hip Abd strength and resultant loading at the knee during walking	Lewinson et al., 2014.	Walking	Seemed more likely that **Hip Abd weakness was a consequence of OA rather than a predisposing factor**.
Is hip strength a risk factor for PFP? A systematic review and meta-analysis.	Rathlef et al., 2014.		There may be **no association between isometric hip strength and risk of developing PFP**.
Hip Abd function in individuals with medial knee osteoarthritis: Implications for medial compartment loading during gait.	Rutherford et al., 2014.		There was **no clear relationship between Hip Abd muscle strength and temporal knee adduction movements**
The influence of changes in trunk and pelvic posture during single leg standing on hip and thigh muscle activation in a pain free population.	Prior et al., 2014.	Single leg standing	The influence of **changes in trunk and pelvic posture during single leg standing** on hip and thigh muscle activation in a pain free population.
Experimentally reduced hip-Abd muscle strength and frontal-plane biomechanics during walking.	Pohl et al., 2015.	Walking	**Short-term reduction in hip-abductor strength was not associated with alterations** in the frontal-plane gait biomechanics of young, healthy men.

HABD: Hip Abduction; Glut: Gluteus; SLS: Single-leg squat; FAI: Femoro- acetabular impingement.; LBP: Low back pain; PFP: Patella Femoral pain; Hip Abd: Hip Abductor.

Table 4 demonstrates the complexity of movement patterns and muscle action and thus the importance of recognizing and addressing concomitant compensatory injury patterns associated with groin and hip pathology.

The complexities of the effect of posture on the hip abductor mechanism and the relationship of anticipatory Gluteus Medius activity to pelvic and knee stability have been validated over the past years (Berry et al., 2015; Kim et al., 2016). Deficits in hip abductor muscle morphology, strength, activation patterns and functional control of the pelvis on the femur have been demonstrated in those with osteoarthritis of the hip (Arokoski et al., 2002; Sims et al., 2002), tibio-femoral osteo-arthritis (Chang et al., 2005), patella-femoral pain (Cowan et al., 2009 and Mascal et al., 2003) and iliotibial band syndrome, (Fairclough et al., 2007 and Fredericson et al., 2005).

Grimaldi (2011) re-affirmed the close association between hip abductor function and segmental alignment of the femur, pelvis and trunk and discussed the significant effect daily postural habit may have on hip abductor muscle structure and function. Identifying negative postural habits such as standing 'hanging on one hip' in adduction, or with the legs crossed in bilateral adduction may have significant impact not only on short term, but on long term outcomes. Thus assessment of an athlete's activities of daily living is a most important part of evaluation of the athlete and possibly prevention of groin and hip pathologies. Over the years, I have observed that clinicians working with sportsmen and women often don't realise that the problem with the hip or groin is as a result of their activities of daily living, rather than the sport itself. I, myself only reached this conclusion after many years of practicing in the sports world.

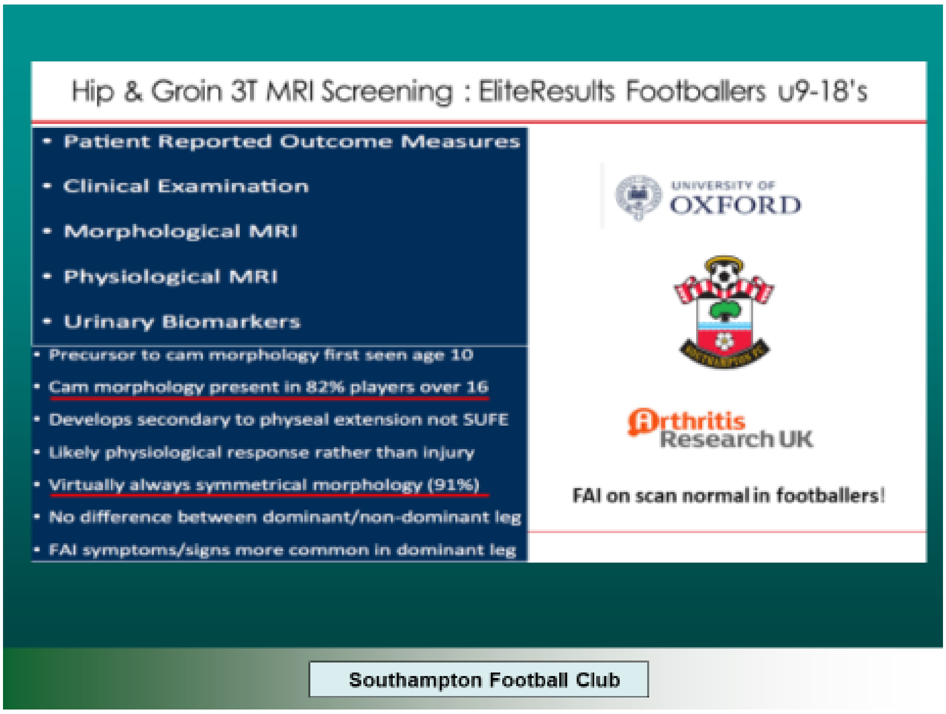
Outcome of these studies: The above studies and those in Table 3 re-affirm the effect that the hip joint muscles have on the kinetic chain, particularly the lower limb joints and muscles. Thus a thorough assessment of the entire kinetic chain, with evaluation of thelateral stability muscles should be mandatory for all patients. The patient's activities of daily living, as well as in their respective sport, require thorough appraisal and all these findings should be interpreted together, rather than independently.

5b ii. Further relevant Functional Tests for hip and groin pain

There are many different functional tests, some of which are validated and others useful anecdotal tests. I do not think that we should be restricted by research only. Clinicians have the power to improvise and develop functional tests specific to the sport (and position within the sport). My years of being very involved with different sports has taught me that we still have a way to go regarding specific sports tests, but if clinicians took ownership, it is possible to develop meaningful functional tests. I think of the PNF, hamstring and shoulder tests that I developed due to the problems that I encountered regarding return to training and matches in sport. They were extremely meaningful and accepted by the coach and player. Retrospectively, I wish I had these tests researched and validated. I believe that as clinicians we have in our scope opportunities to develop tests specific to the functionality of the athlete and then we should be interacting with the research team to authenticate the particular tests.

A useful study identified specific differences and correlations for several biomechanical variables during a single-leg landing, a single leg squat, a double-leg landing, and a double-leg squat (Donohue et al., 2015). The outcome was that individuals are likely to demonstrate different profiles of injury risks when screened using different tasks. They described double-leg landing task as a priority until specific risk factors have been identified using other tasks. Thus the clinician should take cognisance of these studies and undertake a number of tests, using clinical reasoning to achieve a satisfactory outcome.

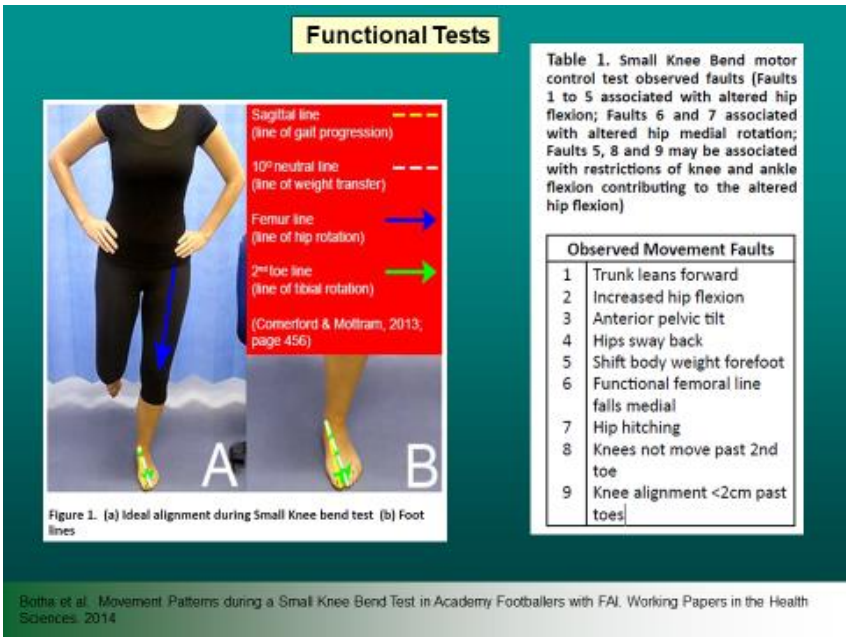
Slide 106



It is of note that Southampton Football Club (with whom I have had ongoing discussions), has been following an excellent groin and hip prevention protocol based on screening, including many of the functional tests as described below and have the least problems in Premier League (Slide 106).

- Small Knee Bend Test

Slide 107



Wright presented at the Football Medical Association Conference (Midland, United Kingdom, May, 2016) on screening of the hip and groin, including gym based and field based interventions. He discussed the study evaluating players from Southampton Football Club (Botha, 2014) as per Slide 107 showing uncontrolled movement during a small knee bend test in young footballers with FAI. Their preliminary findings suggest impaired movement control exists in academy footballers with symptomatic FAI. Identifying and classifying these movement faults may prove necessary for effective prevention and management of symptoms by controlling movement adaptations. However, they ascertained that further studies are warranted to validate these findings against motion analysis technology and muscle activity using electromyography, and to further understand the mechanisms of movement dysfunction.

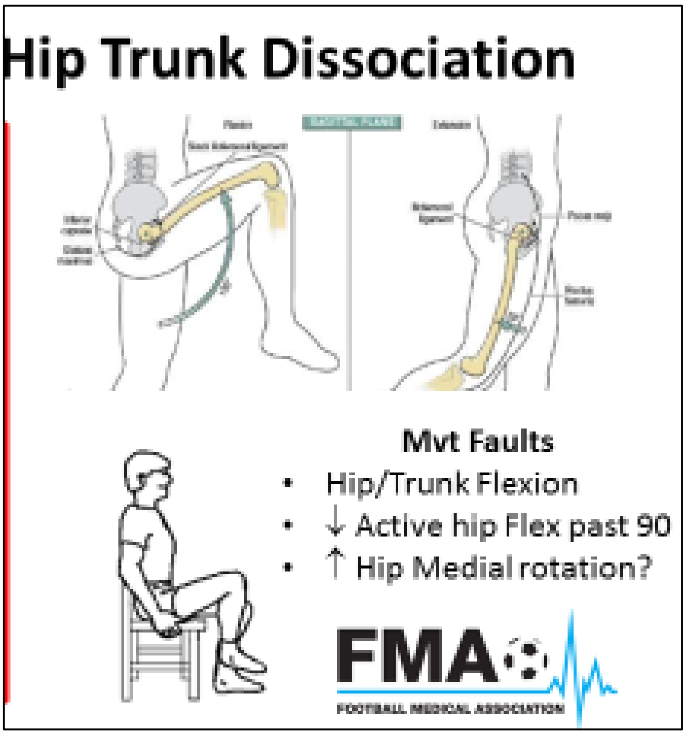
- **Inner Range Holding test**

Slide 108

Another useful test was shown by Gimpel (Warwick Hip Meeting, 2016) and I have found this test to be most effective in analysing the strength of the hip flexors in inner range of motion (Slide 108). It is interesting to notice how few athletes are able to hold this inner range static position for a reasonable time, the weakness of which I believe may be a precursor for groin or hip problems. My experience with cricket bowlers and the often sustained injury of the ilio-psoas muscle, highlights this fact and the obvious weakness which requires strengthening in inner range (and with bowlers a long lever i.e. the leg in full extension). Practically, I have added in the long lever inner range holding test in standing for fast bowlers or when specifically required in a sport.

- Hip Trunk Dissociation

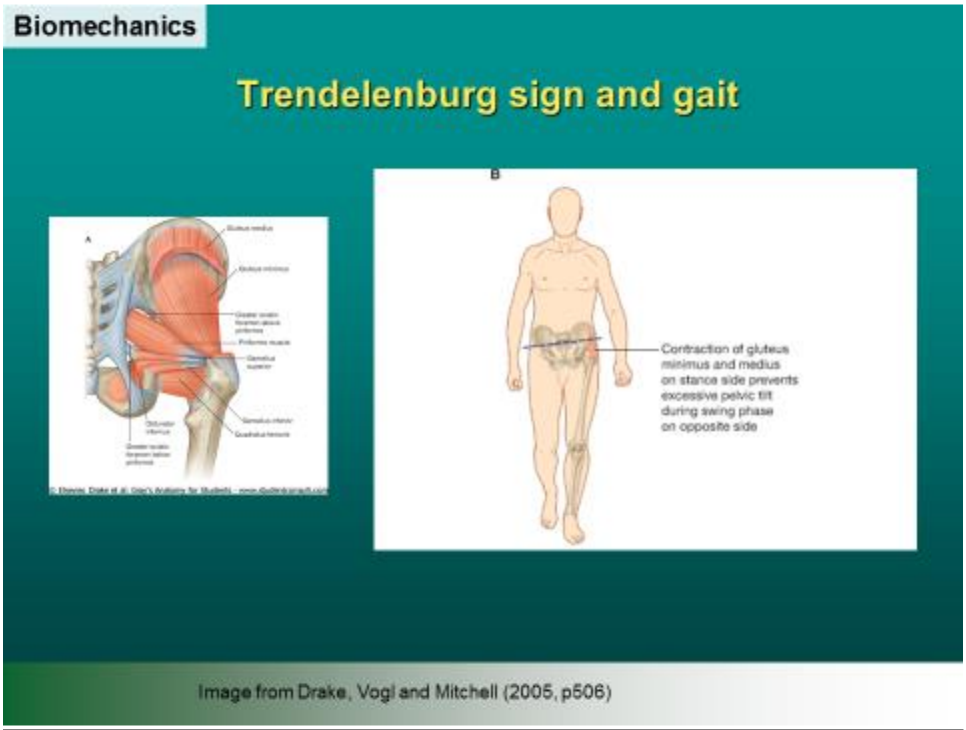
Slide 109



The hip dissociation test was implemented with apparent success by Southampton Football Club (Slide 109). According to S. Wright (personal communication, March 26th 2019), identifying dysfunction of hip and pelvis during this test has become a key test. However, he does concur that with these players with a history of groin pain and FAI, for significance they need to be compared against matched controls who were asymptomatic to get specific validation. He maintained that they had a significant reduction in surgical cases, which they attributed to the pre- activation strategies and the introduction of movement control. I have been using this test with groin, hip and knee pathologies and have found the test to be most useful for evaluating weakness or impaired movement around the pelvic area, particularly in standing.

- **Trendelenburg Test**

Slide 110

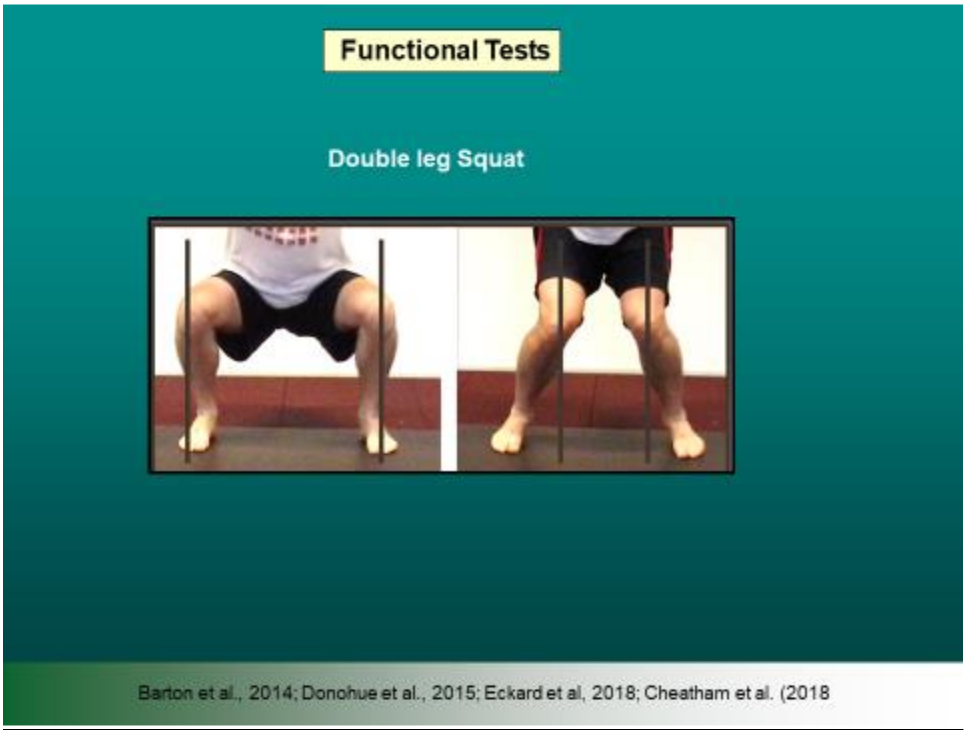


For many years the Trendelenburg test has been used by clinicians to detect hip abductor muscle weakness (Slide 110). Varying opinions regarding the Trendelenburg test were produced e.g. Kendall et al. (2010 and 2013) who discussed the fact that hip abductor strength may not be the only contributing factor in controlling pelvic stability, Bird et al. (2001), who declared that the Trendelenburg test was the most sensitive and specific physical sign for the detection of Gluteus Medius tears and Fujita et al. (2017), who concluded that a modified Trendelenburg test improved reliability. Grimaldi (2011) showed that with respect to assessment of the lateral stability mechanism, the clinician needs to determine the ability of the individual to control femoro-pelvic alignment in the frontal plane. This study stated that the traditional Trendelenburg test assessed the frontal plane orientation of the pelvis and trunk. An 'uncompensated' positive test result is described as pelvic tilt occurring towards the non-weight bearing side and a 'compensated' positive test as trunk lateral flexion towards the weight bearing side during single leg stance.

I have found the Trendelenburg test to be most useful in my practice, but am aware that it is one of a number of tests that needs to be undertaken to reach any resultant possible diagnosis. Thus a positive Trendelenburg test is not diagnostic of a specific pathology and as with all tests, needs to be evaluated in conjunction with other clinical signs and symptoms. This factor is being recognised these past years, as opposed to being reliant on one test being the answer to form a specific diagnosis.

- **<u>Double leg squat.</u>**

<u>Slide 111</u>

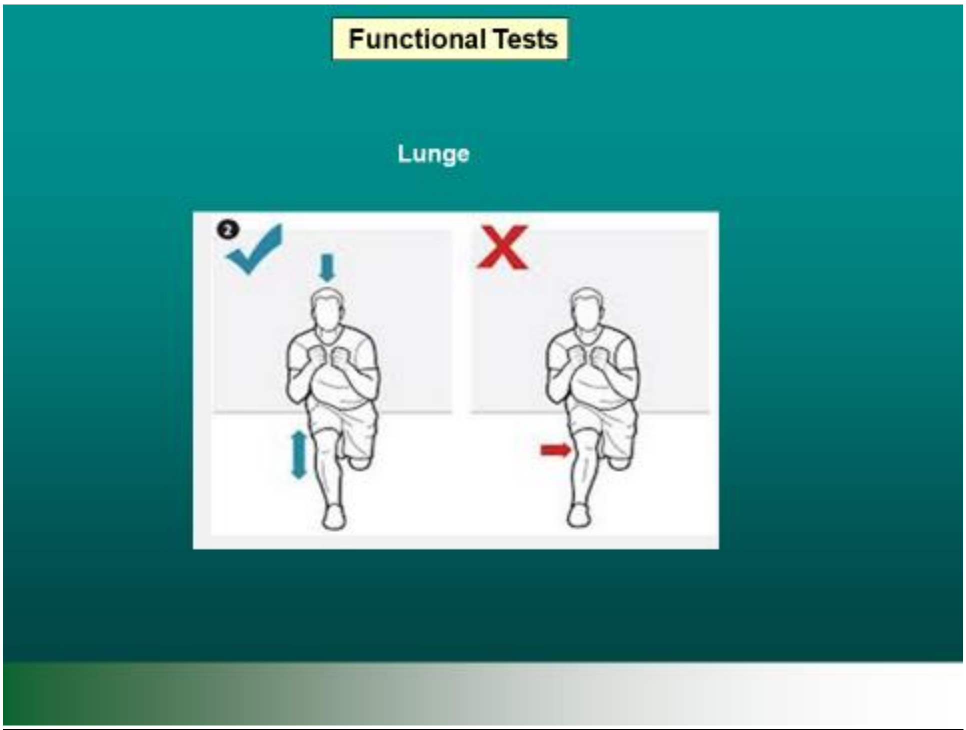


The clinician should consider that individuals are likely to demonstrate different profiles of injury risks when screened using different tasks such as single-leg squat, double-leg landing, and double-leg squat task (Donohue et al., 2015) (Slide 111). Barton et al. (2014) compared single-leg squat with double-leg squat task and indicated that single-leg squat may be more appropriate than double-leg squat task, particularly to facilitate strength gains of Gluteus Medius and Gluteus Maximus. Another comparison of single-leg squat and double-leg squat task in National Collegiate Athletic Association players, showed that movement quality assessed on both the double-leg squat task or single-leg squat had greater incidence of lower extremity injury than those with non-poor movement quality (Eckard et al., 2018). Essentially, there is sparse evidence based medicine for the double-leg squat task and any association with the hip joint. Cheatham et al. (2018) stated that future research should focus on the association between common hip conditions and squat performance.

Clinically, I find this to be a most useful test for identifying a knee valgus and possible hip medial rotation due to hip stabilising muscle weakness.

- **Lunge**

Slide 112

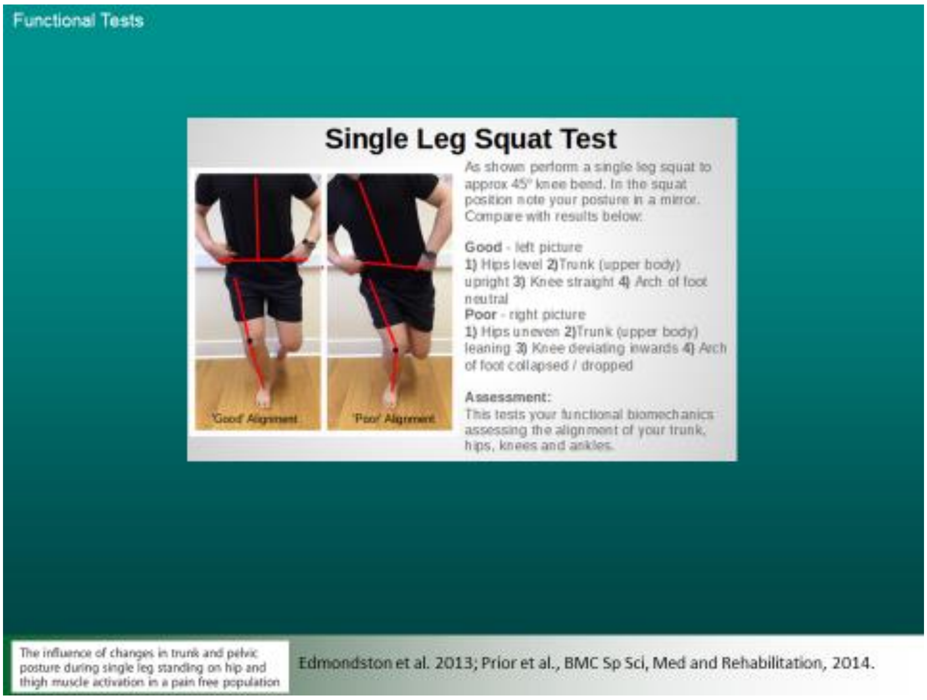


Slide 112 shows the much used lunge test. Most of the lunge test studies explain the ankle dorsiflexion range of motion e.g. Powden et al. (2015) or potential ACL problems e.g. [2]Alkjaer et al. (2009) with minimal evidence for any hip connection and the lunge test. A test evaluating inter- and intra-observer reliability and discriminative validity of three movement control tests: 1) standing knee-lift test; 2) static lunge test; and 3) dynamic lunge test, showed an overall good agreement for the composite, scores and for the majority of the included test component. Although reliable, they advised that the tests should not be used for diagnostic purposes, but should be further evaluated toward predicted validity (Granstrom et al., 2017).

I, personally, value this test, as it appears to demonstrate a number of movement malfunctions around the pelvis and the lower extremity. Although there is a dearth of research on fatigue and neuro-motor control, I believe that this is particularly the case with fatigue when the neuro-motor system is not functioning to full capacity. This has been the case when I have undertaken this test before and after training.

- Single Leg Squat

Slide 113



The single leg squat is commonly used for subjective assessments of general biomechanical function, injury risk, as a predictor for recovery and as an outcome measure of rehabilitation (Barker-Davies et al., 2018) (Slide 113).

Table 5: Variations of outcome of the Single Leg Squat (SLS).

Author	Outcome
Claiborne et al., (2006): Prins and Van der Wurff, (2009); Baldon et al., (2009);	These studies using the SLS and with systemic reviews demonstrated that there is **a definite link between hip movement / strength and knee movements / PFP.**
Nakagawa et al. (2012).	Trunk, pelvis, hip, and knee kinematics, hip strength, and Glut muscle activation during a SLS in males and females with and without PFP showed that despite many similarities in findings for males and females with PFP, there **may be specific sex differences that warrant consideration in future studies and when clinically evaluating and treating females with PFPS.**
Weeks et al. (2015).	**Sex differences in SLS kinematics appear to apply only at the hip**, **knee, and pelvis** and not at the trunk. **Fatiguing exercise**, however, produces changes at the trunk and **pelvis** with little effect on the knee.
Khuu et al. (2016).	The mechanics of the trunk, pelvis, and lower extremity during the SLS were **affected by the position of the non-stance leg** in healthy females. Practitioners can use these findings to distinguish between SLS variations and to select the appropriate SLS for assessment and rehabilitation.

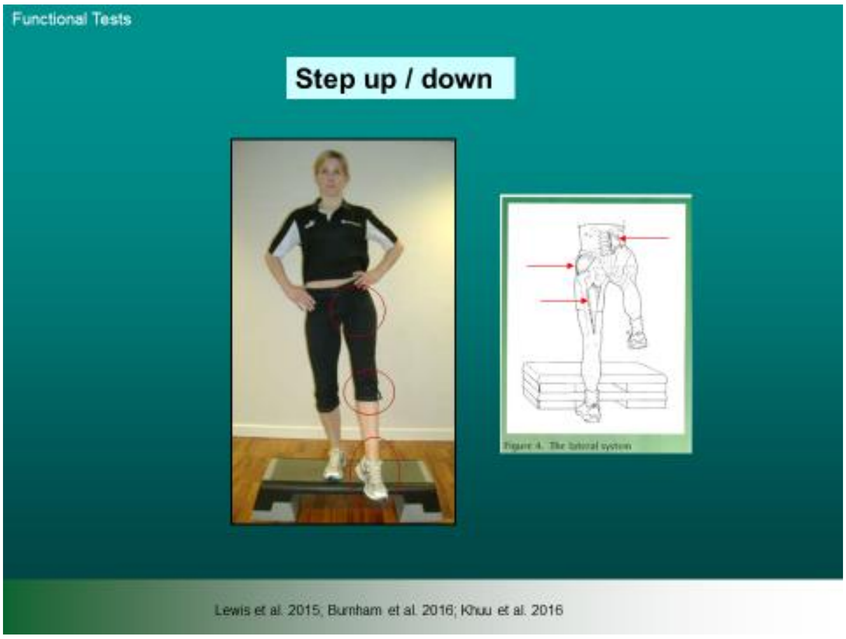
Marshall et al. (2016).	For chronic athletic groin pain, an SLS **did not provide meaningful insight into hip and pelvis control or loading during sporting movements** that are associated with injury development. The usefulness of an SLS test in the assessment of movement control and loading in Adductor Groin Pain patients **is thus limited.** The SLS provided moderate insight into knee control while landing and therefore may be of use in the examination of knee-injury risk.
Barker-Davies et al. (2018).	Although they found that comparisons between clinicians were unreliable, they supported repeated use of SLS by a single practitioner. They concluded that poor validity against kinematic data suggested that **clinicians use additional information** upon which they find agreement such as estimating kinetics e.g. correlation between hip internal rotation moment and subjective ratings whereby clinicians are trying to identify excessive abnormal loading.
Warner et al. (2019)	**Due to variation in how the SLS was performed, it was not possible to determine specific biomechanical parameters** that distinguish between pathological and non-pathological groups

SLS: Single Leg Squat; PFP: Patella Femoral Pain; PFPS: Patella Femoral Pain Syndrome.

Although I have found value in identifying any biomechanical weakness when assessing the single leg squat, Table 5 demonstrates the varied opinions and outcomes regarding this test. These valuable comments need to be assessed accordingly and has been an awakening for me e.g. position of the non-stance leg or gender differences. Further studies that discuss the relevance of single leg squat include those of Crossley et al. (2011); Edmondston et al. (2013); Nakagawa et al. (2012) and Prior et al. (2014).

- <u>Leg Step down</u>

<u>Slide 114</u>



The single leg step-down test is often done in conjunction with single leg squat, both of which are commonly used functional tasks to assess movement patterns (Burnham et al., 2016; Khuu et al., 2016; Lewis et al., 2015) (Slide 114). As has been discussed previously, research has shown a connection between lower extremity injury and weak hip muscle strength and the single leg step-down is an excellent clinical tool to assess the functionality of the pelvis and hip joint muscles during this test (Ireland et al., 2003). Khuu et al. (2016), by performing a biomechanical comparison of three variations, demonstrated in their study that not all single leg squats are equal. The mechanics of the trunk, pelvis, and lower extremity during the single leg squat were affected by the position of the non-stance leg in healthy females. Thus practitioners should bear in mind these findings to distinguish between single leg squat variations and to select the appropriate single leg squat for assessment and rehabilitation, be it for any assessment, including groin and hip assessment. With this explicit knowledge I now look for all these nuances when assessing a patient.

Burnham et al. (2016) demonstrated that the single leg step-down test can be used as a screening tool to identify individuals with weak trunk and hip strength. The fact that it is agreed that further research should evaluate the single leg step-down as a screening and/or return-to-play test and that more studies are required to specify the actions of the pelvis and hip muscles during this test, nonetheless, I believe that practically this test is a good indicator of any malfunction and should be undertaken.

- Wall Running

Slide 115

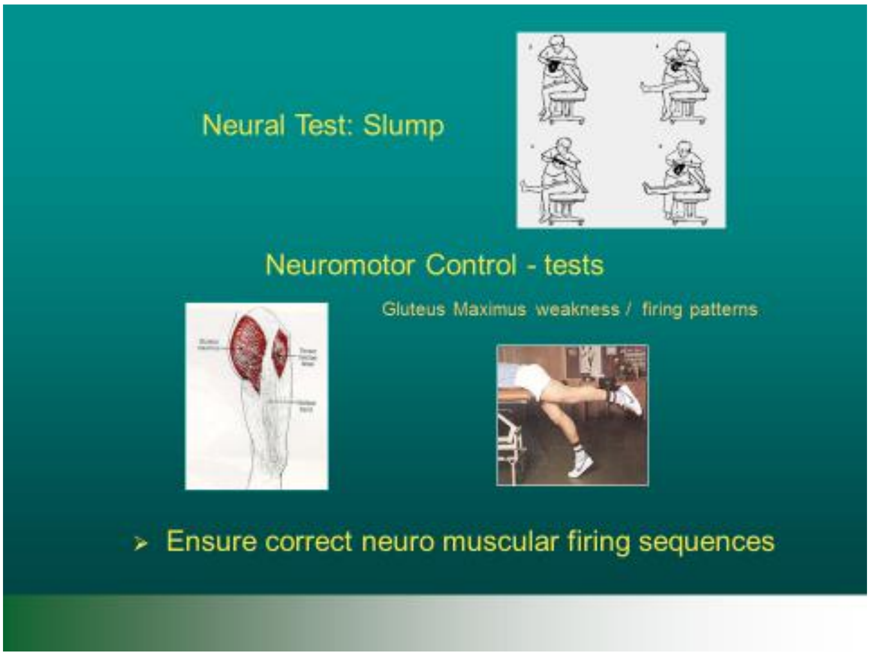
A functional test that I use frequently for all my sportsmen and women is my devised wall running test. The player has to stand with one leg against the wall in a 90-degree knee flexion position. The other leg is planted on the ground. He then has to squat to approximately 60 - 80 degrees slowly and controlled whilst swinging the opposite arm to the bent knee (Slide 115). It is imperative that he goes down in a plumb line position and does not extend his buttocks behind him. One starts slowly and then can increase the speed. Further, I suggest that if this is easy for them, a balance mat is added.

There is no scientific evidence with regards to this test and it is subjective, based on the clinician's assessment. However, having seen the benefits of assessing functional discrepancies in my athletic patients when performing this test, it would be useful if studies were undertaken to verify this test. Regardless, having developed and used this functional test over the past 20 years with excellent outcome, I would strongly recommend its usefulness in assessing the hip and groin area (especially lateral hip stability), as well as the entire kinetic chain and should be used in conjunction with a number of other functional tests. As the slide above shows, the athlete performing this test is a national cricket spin bowler who had low back problems. I analysed his movement on this test and identified that his gluteal stabilising muscles were not functioning well, particularly with fatigue. This was clearly seen by the "dropped" pelvis on one side (similar to the Trendelenburg sign). With a comprehensive specific rehabilitation programme to strengthen the hip stabilisers, he returned to high level of play with no further problems. I also believe that this strategy not only improves the current pathology, but may be a factor for strengthening relevant muscles and thus improving performance. Whilst with the Stormers rugby, I used this movement for many outcomes e.g. when travelling to Australia or New Zealand, the players had to do this exercise, albeit 3 am in the morning, or no matter how fatigued and irritable they may have been, due to the very long travelling and different time zones. This was to train the neuro-motor system to handle fatigue and ill temper, particularly for the end of matches. The Coach was in favour of this strategy. I share this strategy in all my presentations and I believe it is used by many clinicians in UK, SA and India.

5b iii. Neuromotor Control

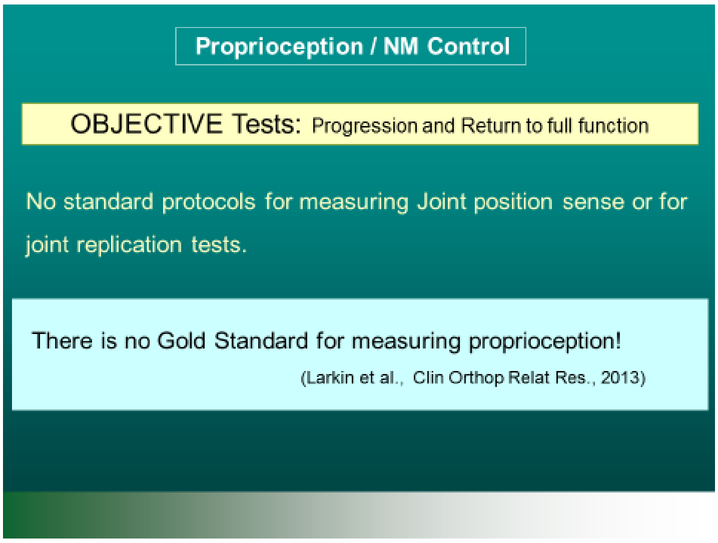
As has been discussed in Chapter 4 - Functional Anatomy, neuro-motor control is the cornerstone for the functionality of the entire body. Studies have shown that there is impaired performance of the hip and groin area in the presence of certain pathologies which may reduce control of dynamic movements (Cowan et al., 2009; Martelli et al., 2011). Hatton et al., (2014) explored the relationship of balance control and hip chondropathy in young adults during a dynamic single leg squat with eyes open and a single leg squat task with eyes closed and whether hip range of motion and muscle hip strength was correlated with balance measures in adults with chondropathy. The outcome demonstrated reduced balance performance during a single leg squat in individuals with chondropathy and it was suggested that early signs of hip joint degeneration may impair postural control during dynamic tasks. Knowledge of the impact of pathologies on neuro-motor control may assist in the establishment of early identification strategies for individuals with associated balance deficits in order to provide a targeted approach to rehabilitation as a prevention strategy.

Slide 116



The Slump test is a clinically useful neural test (Maitland et al., 1985; Urban et al., 2015) and may help in differentiating the fact of any referred neurological pain from the lumbar spine (Slide 116). The Gluteus Maximus firing patterns (the prone leg extension test) is a valuable neuro-motor control test which is used to evaluate the function of the lumbo-pelvis, the sequence of movement and possible effects on structures around this area (Bruno et al., 2014) (Slide 116). From my experience, I have found this test to be useful, as long as it is analysed correctly and is not considered to be sacrosanct for a one off diagnosis. This was shown by Lehman et al. (2004) whose outcome was that a consistent pattern of activation in the prone leg extension test was not found and a variability was seen across subjects.

Slide 117



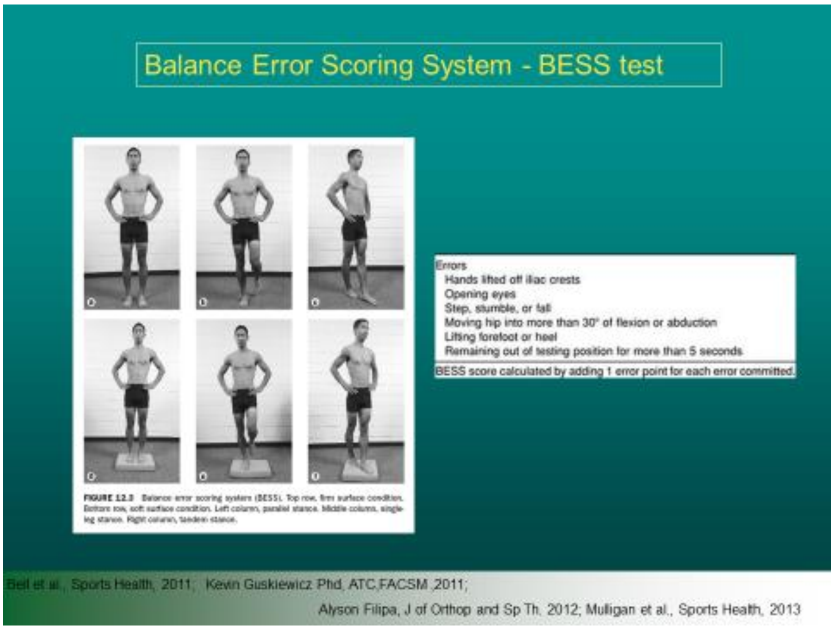
Essentially, there is no gold standard for objective measurement for proprioception (Larkin et al. 2013) (Slide 117) However, very worthwhile functional balance tests which are used widely are the Balance Error Scoring System (BESS test) (Mulligan et al., 2013), the Star Excursion Balance Test (SEBT) (Gribble et al., 2013) and the Y (YBT) test (Fullam et al., 2014).

Highly validated Neuromotor Tests

Table 6 and the slides below, show the most utilised tests undertaken by clinicians world- wide for assessment of any neuro-motor deficiencies due to the validity and the positive outcomes.

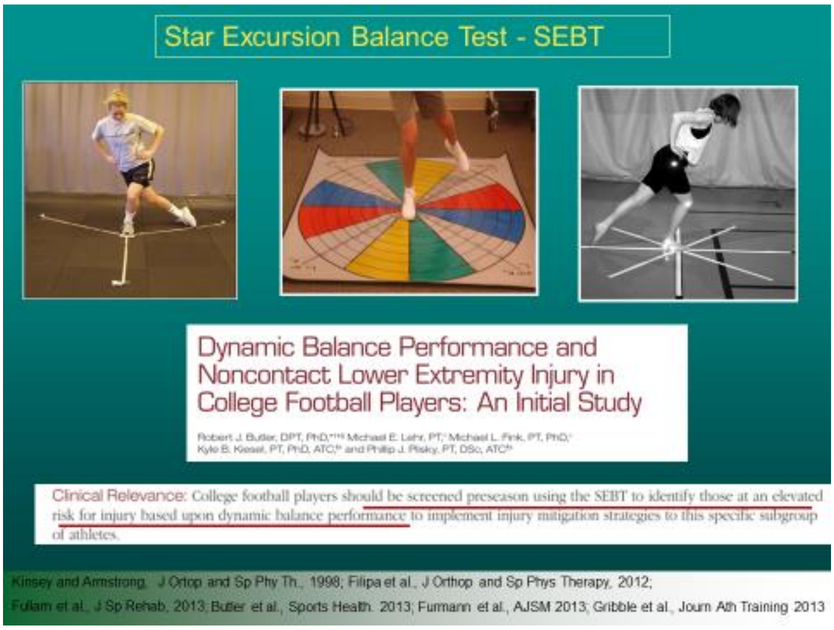
1) Balance Error Scoring System - BESS Test

Slide 118



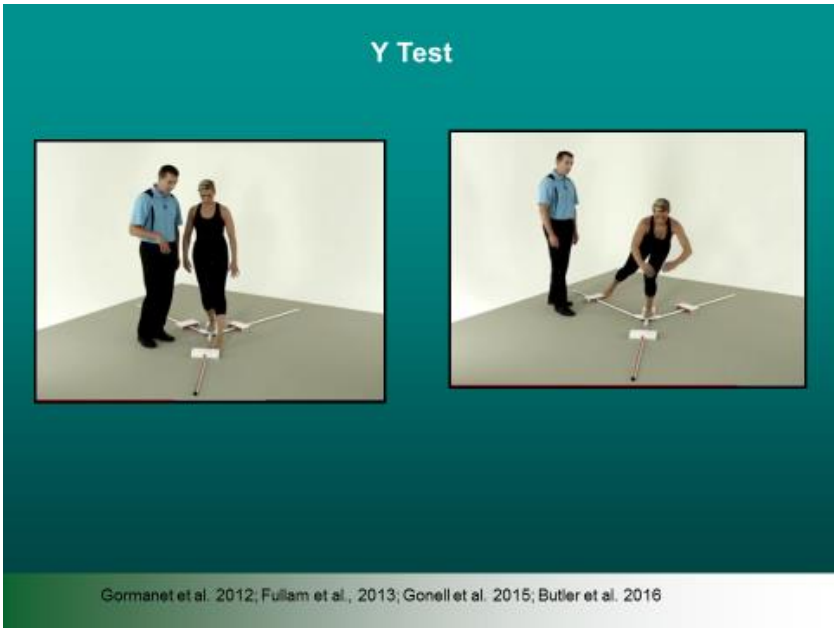
2) Star Excursion Balance Test - SEBT Test

Slide 119



3) YBT-LQ: Lower Quarter Y Balance Test

Slide 120



Slides 118 -120 clearly show each test which is used by most clinicians and features in many presentations / workshops. The YBT-LQ Test is a modified version of the SEBT test and is used extensively in practice (Gribble et al., 2013). Table 5 below shows the many studies affirming the validity of these balance tests. However, there are minimum studies regarding groin and hip and neuro-motor control (Mendis et al., 2014).

Table 6: Highly validated Neuromotor Tests

Test	Author	Outcome
BESS	Bell et al. (2011).	The BESS test can **detect balance deficits** in participants with **concussion and fatigue**
BESS	Alsalaheen et al. (2016).	The **effects of gender on the BESS performance** support the gender-specific reference values reported in this study. These reference values provide benchmarks for clinicians when interpreting the BESS in the absence of individual baseline scores.
BESS	Ozinga, (2018)	Despite the widespread use of the BESS, **a fundamental gap exists in applying this tool to young athletes**, as normative values regarding **concussion** are lacking in youth, high school, and collegiate athletes. Performance on the BESS depended on sex and age, particularly in youth athletes. These sex- and age-specific normative values provide a reference to facilitate and unify clinical decision making across multiple providers caring for youth athletes with concussions.
SEBT	Gribble et al. (2013).	SEBT for dynamic postural control shows that although the **intrarater reliability of the SEBT is excellent, few authors have determined interrater reliability**. Preliminary evidence has shown poor reliability between assessors
SEBT	Johansson and Karlsson (2016).	Recommended that clinically one should **combine SEBT in the posterolateral (PL) and posteromedial (PM) direction with other tests on patients with FAI.**
SEBT	McCann, 2017.	The **chronic ankle instability group's** isometric hip strength significantly influenced dynamic postural control performance as shown on the SEBT test
SEBT	Patel et al. (2018).	**The normative values of SEBT** can be used by physical therapists, coaches and athletic trainers in order to interpret and compare with the normal values which will help to find out the risk of injury.
SEBT	Jaber et al. (2018).	**Alteration in proximal and distal muscle activity appears to negatively affect postural control** and quality of movement, which may lead to prolonged functional impairments
YBT-LQ Test	Gorman et al. (2012).	**Demonstrated the differences in dynamic balance scores in one sport versus multiple sport in high school athletes using the YBT-LQ.**
YBT-LQ Test	Kang, (2015).	**Hip flexion was the best single predictor of PM and PL** normalized reaches of the YBT-LQ. The combination of hip flexion and ipsilateral trunk bending and the combination of hip flexion and contralateral trunk bending accounted for 69% and 80% of the variance in the PM and PL normalized reaches of the YBT-LQ, respectively.
YBT-LQ	Smith et al. (2018).	79% of the high school athletes presented with at least one asymmetry in YBT-LQ reach distances. **Moderate reliability** in the **PL and PM**

Test		**directions** warrants re-examination of the definition of asymmetry in these directions.
YBT-LQ Test	Schwiertz et al. (2019).	The observed values suggest that the **YBT-LQ is a reliable test** and suitable to detect changes of dynamic balance performance in healthy adolescents aged **11-19 years**
Chimera and Warren, (2016).		Review of: **FMS, SEBT test, Y Balance Test, Drop Jump Screening Test, Landing Error Scoring System, and the Tuck Jump Analysis**. **Outcome: Highlighted the need for collaboration between clinicians and researchers to ensure validity of clinically meaningful tests so that they are used appropriately in future clinical practice.**
Bird and Marwick, (2016)		Evaluation of the **Functional Hop Test, BESS test, the Tuck Jump Assessment, the Lunge Test, and the SEBT test** **Outcome:** Each of these assessments creates movement demands that allow for easy identification of inefficient and/or compensatory movement tendencies

BESS Test: Balance Error Scoring System; WBLT: Weight-Bearing Lunge Test; ANT: Anterior Reach Test; SEBT: Star Excursion Balance Test; YBT-LQ: Lower Quarter Y Balance Test; FMS: Functional Movement Screening; PL: Posterolateral; PM: Posteromedial

Table 6 explains balance studies with detailed analysis. Clinicians require this knowledge in conjunction with the clinical application of these tests. Further, what is required is normative data for each sports and the specific requirements involved e.g. Hudson et al. (2016).

Conclusion - Functional Tests

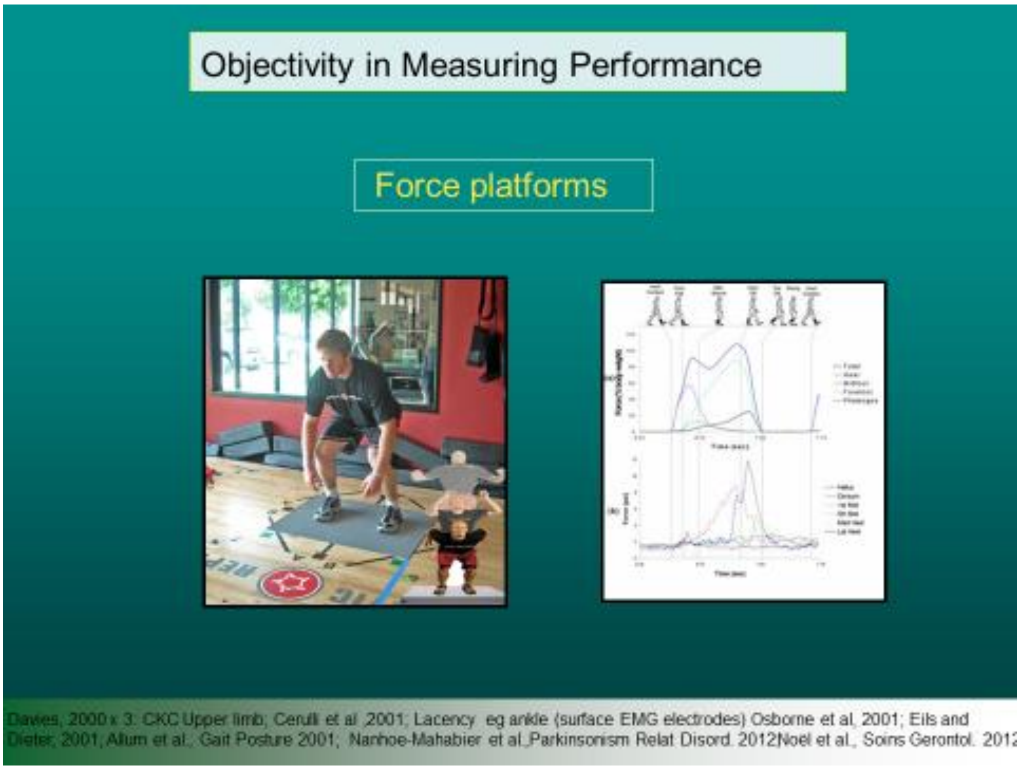
The reliability of functional performance tests has not been established on patients with hip dysfunction (Kivlan and Martin, 2012). Although many of the studies are mostly related to pathologies other than the hip and groin, clinicians should bear in mind the findings from the studies and use clinical reasoning to select the appropriate tests for assessment and rehabilitation. Interpretation of these findings by experienced clinicians may identify nuances for individual patients that are missed when data is collated during research studies. Further one should take note that individuals are likely to demonstrate different profiles of injury risks when screened using different tasks. Thus again, I confirm that each clinician has the opportunity to analyse these tests, as well as use their initiative to develop relevant tests for each individual in a particular sport.

Movement tests such as those mentioned above, have gained a lot of popularity in the clinical setting as a tool to predict injury and guide injury prevention programs/training. However, clinicians should be aware that various factors like sex differences, previous injury history, and sport participation can influence the accuracy of these screening tests. Therefore, it is important to evaluate the validity, reliability, and accuracy of these tools before implementing them into clinical practice. While these screening tests have been used readily in the clinical field, it is only recently that some of these have started to gain attention from a research perspective. I have utilised many of these functional tests and have found them to be of great value in my overall assessment and subsequent management of my patients with hip and groin pain (as well as other pathologies).

5c. Objectivity in Measuring Performance

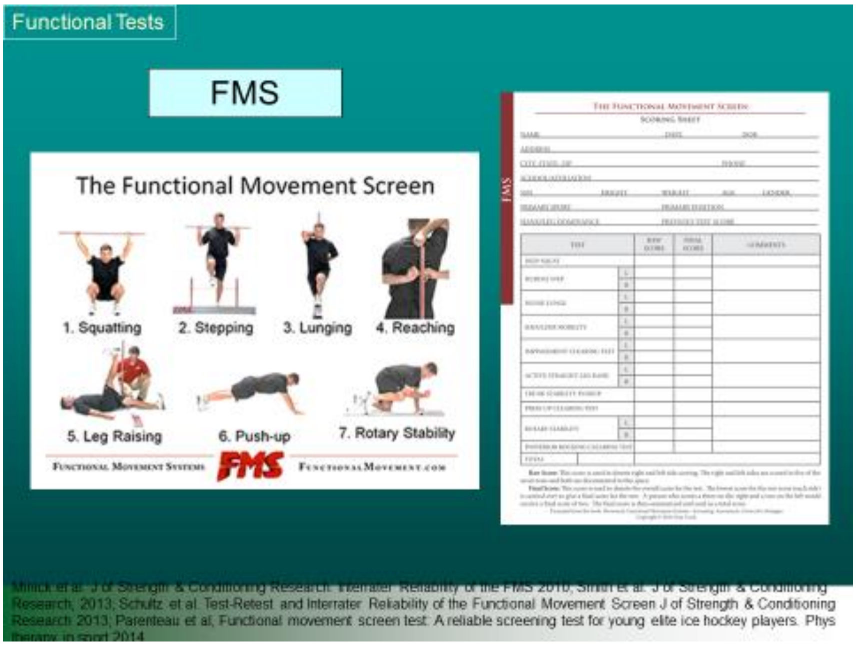
An ongoing issue regarding tests is the difficulty of objectivity when undertaking tests for the hip and groin. It is important that one understands the difference between subjective and objective assessment. If one was totally reliant on objective research, many practically applied, useful tests would not be undertaken. Many of the tests are largely subjective and heavily influenced by the clinician's experience. I have developed a number of tests over the years in my practice which have not been researched, but nonetheless have given me insight into patient dysfunction and has guided me to address the deficits in the functional movement of the athlete. An example of this are my hamstring tests which I developed for the Super 14 Rugby team. A PhD student is currently investigating the validity of these 7 tests. It would be useful if the practical tests which clinicians devise could be translated into research and thus possibly become more research based and thus more acceptable.

Slide 121



A number of researchers have attempted to improve the objectivity of functional tests by measuring the outcome e.g. the force platform (Meshkati et al., 2011 and Quatman-Yates et al., 2013) (Slide 121). The value of the force platform has been demonstrated by showing relevant normative values in male junior soccer players (U16, U17 and, U18 years) (Petridis et al., 2019).

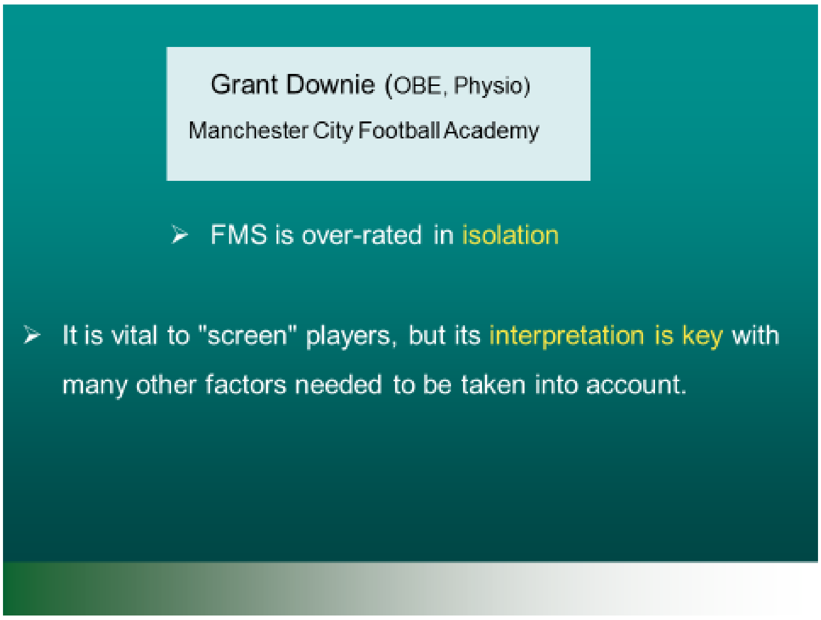
Slide 122



The Functional Movement Screen (FMS) is used extensively in clinical practice and there are many studies to show the validity of this test (Slide 122). Many studies claim that FMS may be a useful tool in the screening of the athletic population with good inter-rater and intra-rater reliability (Berry et al., 2015; Cuchna et al., 2016; Leeder et al., 2016; Parenteau et al., 2014; Teyhen et al., 2012). However, not all studies showed validation of this screening method (Bring et al., 2018; Dorrel et al., 2018; Moran et al., 2016). FMS subtests (as well as the Y-BT test) were shown to be weakly or moderately correlated with self-reported hip/groin problems. Newton et al. (2017) showed that there was no relationship between Functional Movement Screening score and injury. It was unable to predict any non-contact injury among English Premier League youth academy players. Thus they suggested that the Functional Movement Screening should not be used for risk stratification among young elite soccer players since the composite score was unrelated to injury likelihood.

Thus, it was recommended that these tests should be investigated further in adolescent footballers because they may have potential to predict hip and groin problems (Linek et al., 2019).

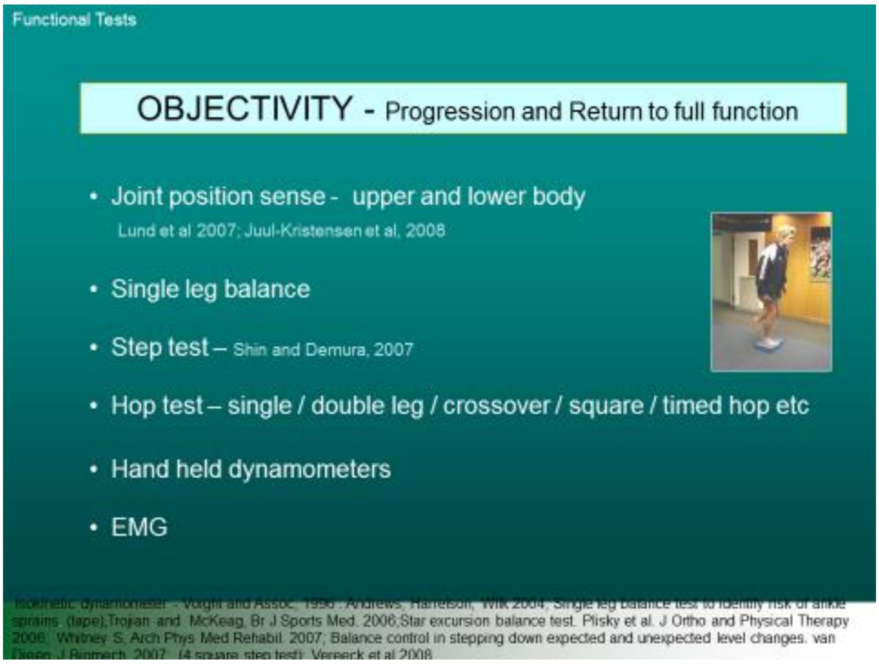
Slide 123



G. Downie, Manchester City Academy physiotherapist (personal communication, March 14, 2016), expressed a strong conviction that FMS should not be used in isolation and that although it was vital to screen players, the key point about FMS was the interpretation and should be used in conjunction with other relevant tests (Slide 123).

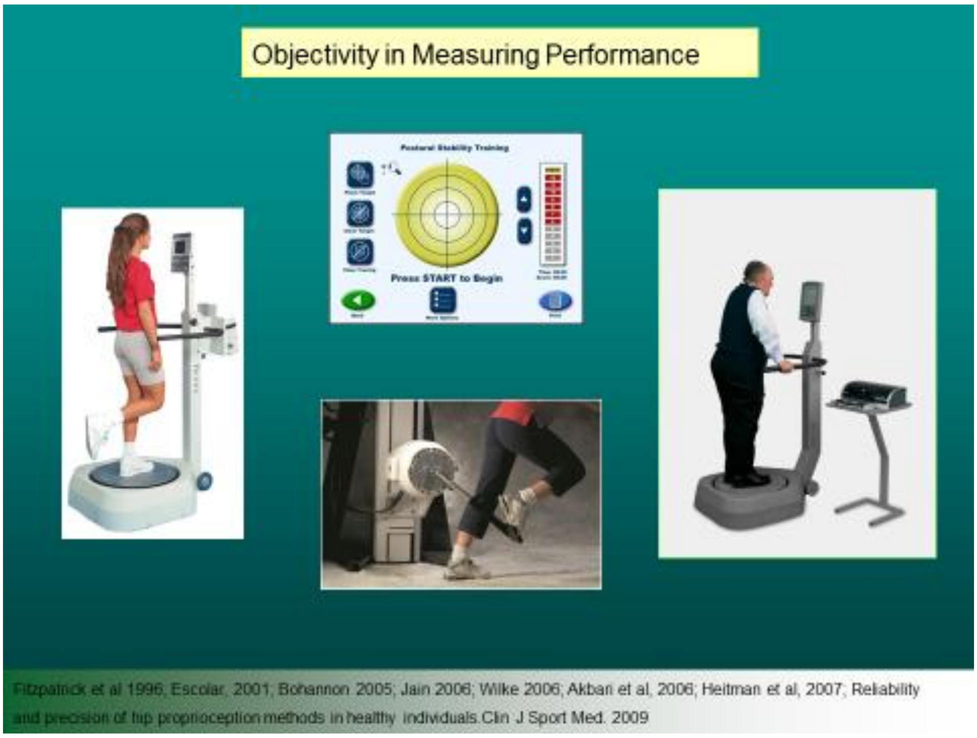
Thus results for the use of FMS are conflicting and may not be useful for all populations. However, from a clinical perspective when combined with clinical reasoning of a clinician there is definitely merit to this tool. I personally, do believe that there is a role for FMS and hip and groin assessment. However, the costs involved, the interpretation of the tests and the fact that this should not be the single assessment, should be taken into account.

Slide 124



Although there is some debate as to the objectivity of Electromyography, studies do verify this objectivity (Khamis et al., 2015) (Slide 124). The Electromyography is mostly useful in research e.g. Serner et al., 2014 (EMG evaluation of hip adduction exercises for soccer players); Kim et al., 2016 (usefulness of isometric hip adduction during the plank exercise to enhance abdominal muscle activity); Hides et al., 2016 (Adductor Magnus and Adductor Longus muscles are recruited to different extents during a simulated weight-bearing task); Steinberg et al., 2017 (hip muscle performance variables are related to leg, ankle and foot injuries) and Zaferiou et al., 2017 (lower extremity control for ballet dancers during turns initiated with and without hip external rotation). However, while Electromyography provides interesting insights into testing protocols and interpretation, it is complex and equipment is very expensive. The use of this in a clinical setting is limited but Electromyography may be useful in research to inform clinical assessment and management.

Slide 125



Isokinetic devices are commonly used to obtain measurements in clinical practice (Slide 125). Correct positioning and testing speeds are important when considering Isokinetic dynamometry (Santos Andrade et al., 2016 and Zapparoli and Riberto, 2016). Amongst others, two isokinetic devices that may be useful are the Biodex and Baltimore Therapeutic Equipment (BTE). There are studies to validate their efficacy (Benjaminse et al., 2009; Bhave et al., 2007; Glave et al., 2016; Rothstein et al., 1987; Wang et al., 2016). However, there are minimal studies specifically on the groin and hip (Biodex: Claiborne et al., 2009; Reimer et al., 2010; Roy et al., 2007. BTE: Fazio et al., 2012; Hoglund et al., 2014; Mutchler et al., 2015; Popovich et al., 2012; Smith et al., 2014; Souza and Powers, 2009). These hip studies are of value, but it would be good if more studies (particularly with the more functional BTE device) could be undertaken with regard to sports movements and functionality.

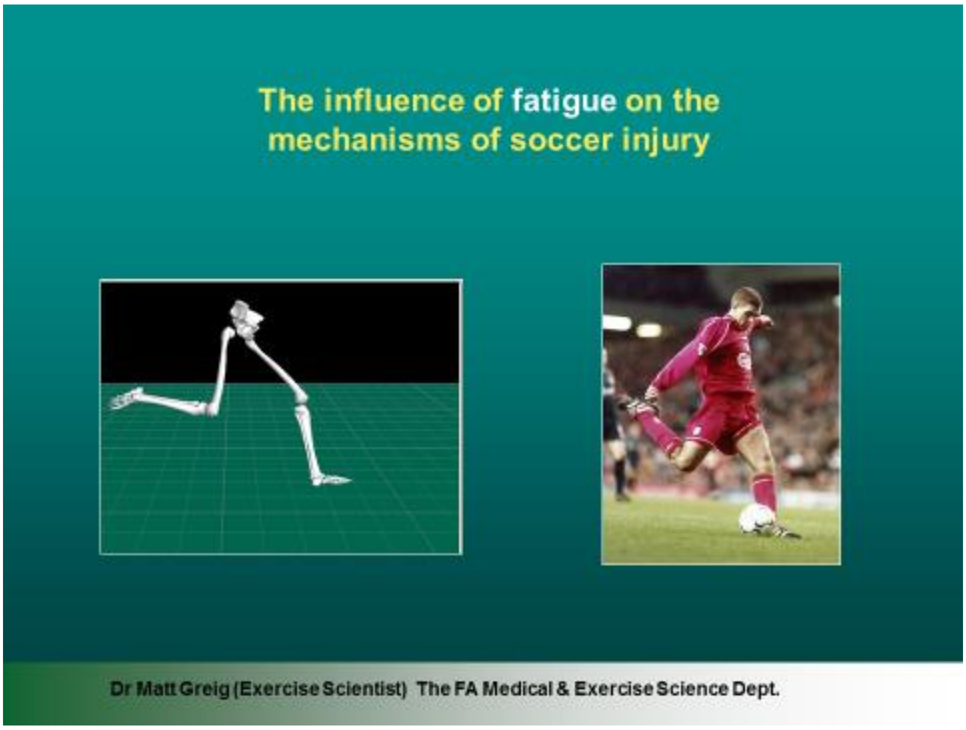
It is positive to have objective assessment when assessing a patient and they have always been popular due to the fact that very comprehensive data is gathered and analysed. However, once again the expense and interpretation is a difficulty when using these isokinetic machines. At one stage many years ago when I was undertaking my Masters degree (2003), these isokinetic evaluations were THE answer. However, although I believe that they were definitely of benefit, I have never wavered from my functional subjective tests (in conjunction with these, where affordable), as my overall management of the pathologies / malfunctions responded positively to my functional assessments.

5d. The Influence of Fatigue

The increase in competition demands in elite team sports over recent years has prompted much attention from researchers and clinicians into the monitoring of adaptation and fatigue in athletes. Although there are many types of fatigue such as acute, chronic, mental, central, metabolic and peripheral, monitoring general fatigue amongst athletes is common practice and the quantification of fatigue status has gained popularity among researchers and clinicians (Thorpe et al., 2017).

Fatigue affects the physical and mental capacity of a sports person in respect of optimal performance (Whitehead et al., 2019). The quantification of fatigue status has gained popularity among researchers and clinicians (Thorpe et al., 2017). Regarding tests, be they specific tests or functional tests, fatigue needs to be factored into the testing protocols. From my perspective of working with many different teams, all tests should be undertaken (especially at the more advanced stage of injury recovery) when the athletes are fatigued e.g. after training. This evaluates the functional status likened to the athletic environment and can give insight with regards to re-injury, performance and return to play. Further, different times of the athletic calendar may show different outcomes regarding fatigue. There may be discrepancies and thus I believe that cognisance of timing of tests should be recognised and recorded on an ongoing basis.

Slide 126



Fatigue was well described by Greig at a Football Association conference (London, United Kingdom, 2012) and in a study which demonstrated a decrease in dynamic balance performance as a function of time (Slide 126). Although this was related to ankle sprains, it may be true of groin and hip problems (Greig and McNaughton, 2014). From my perspective, I believe the clinician should perform most tests after training or once the athlete is fatigued which will give a true perspective of functional performance (or lack of it) when fatigued and thus resultant management. This is currently not common practice and I suggest that it needs to be highlighted in all sports.

5e. Specific Tests

5e i. Background

Most clinicians overestimate the utility of special tests, assuming that they provide more decision-making capacity than they do (Brukner and Kahn, 2017). With so many tests in the clinical domain, combined with uncertainty concerning their accuracy and reliability, it can be difficult for clinicians to determine whether or not the tests they have chosen are providing them with the facts that they require. Further, because tests involve both clinical and interpretive skills, results may differ with the level of the tester’s technical expertise or experience (Hattam and Smeatham, 2012). It could be argued that this is also true of functional tests. From my years of working with athletes, I believe that experience and an in-depth knowledge of the whole kinetic chain in various movement patterns, as explained previously, is the basis for correct functional testing and should be performed in conjunction with the specific tests.

Specific clinical testing of the hip is not nearly as comprehensively investigated as other body parts such as the shoulder and the knee. This dilemma of testing was well articulated in the book by Hattam and Smeatham (2012), whereby they explain each specific hip test in detail and the purpose of each test. However, the tests were shown to generally have low specificity and sensitivity and it proved that it is vital that the clinician always undertakes a battery of tests. Even then, the outcome for a specific diagnosis is arbitrary. Further, the clinicians need to undergo the functional tests in conjunction with these specific tests.

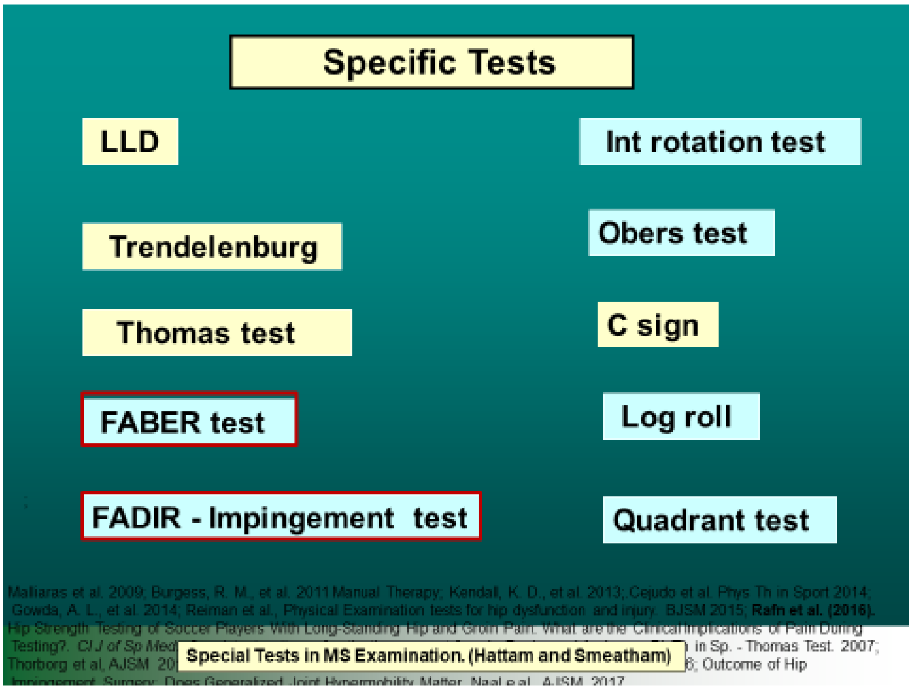
Brukner and Kahn, (2017) in the chapter on hip pain, laid out the specific tests for hip pain and highlighted the valid tests with a double asterisk. Only 4 of all the tests were deemed to be valid and none of the functional tests were reported to be valid. In their table on diagnostic accuracy of clinical tests in patients with hip pain (page 600), they discuss the specificity and sensitivity of each test and all the various permutations involved. I believe it is worthwhile to read all these statements, but to continue to explore and implement the tests with one's clinical reasoning and positive practical outcomes. I constantly analyse and reflect on my management in order to improve my protocols and desired outcomes.

Slide 127

AUTHOR	STUDY
Gowda, et al. Phys Th in Sport. 2014	Gluteus medius strengthening and the use of the **Donatelli Drop Leg Test** in the athlete.
Nevin and Delahunt, J of Sc and Med in Sp Med. 2014	**Adductor squeeze test values** and hip joint range of motion in Gaelic football athletes with longstanding groin pain
Ramskov et al. International J of Sp Phys Ther, 2014.	Normative values of **eccentric hip abduction strength** in novice runners: an equation adjusting for age and gender.
Thomee et al. Knee Surg, Sp Trauma, Arthros 2014	Cross-cultural adaptation to Swedish and validation of the **HAGOS** for pain, symptoms and physical function in patients with hip and groin disability due to FAI
Thorborg et al. BJSM. 2014	Copenhagen hip and groin outcome score (**HAGOS**) in male soccer: reference values for hip and groin injury-free players.
Tong et al. Phys Th in Sp. 2014	Sport-specific **endurance plank test** for evaluation of global core muscle function.
Thorborg et al. BJSM. 2015	**Patient-Reported Outcome (PRO) questionnaires** for young to middle-aged adults with ... f the clinimetric evidence
Rafn et al. Clin J Sp Med. 2015	**Specific Tests** **h LSGP: What are the Clinical Implications**
Kollock et al.,J Athl Training. 2015	Measures of **functional performa**nce and their association with hip and thigh strength
Reiman et al., BJSM. 2015	Physical examination tests for **hip dysfunction and injury**
Mosler et al., BJSM 2015	Which factors differentiate athletes with hip/groin pain from those without? A systematic review with meta-analysis.
Serner et al., BJSM 2016	**Can standardised clinical examination of athletes with acute groin injuries predict the presence and location of MRI findings?**
Rafn et al. Cl J of Sp Med: Official Journal of the Canadian (2016).	**Hip Strength Testing of** Soccer Players With Long-Standing Hip and Groin Pain: What are the Clinical Implications of Pain During Testing?.
Fujito et al., J Orthop Science 2017	**Quantitative analysis of the Trendelenburg test and invention of a modified method**
Azizan et al., Applied Bionics and Biomechanics, 2018.	The effects of leg length discrepancy on stability and kinematics-kinetics deviations: A systematic review.

There are many studies for these specific tests (Slide 127). However, the specificity of each test is questioned on an ongoing basis by researchers and clinicians and the dilemma of obtaining an exact diagnosis by the use of each tests remains complex. The section below will discuss each of these tests as they are currently being used in clinical practice. An understanding and the implications of each test and the general outcome regarding a possible diagnosis is required. Clinically, I have found them to be useful in providing a provisional diagnosis, while the functional tests provide insight into the movement pattern dysfunctions requiring correction. Radiological imaging and team discussion with other experienced clinicians also adds insight.

Slide 128



A number of specific tests have been developed over the years, but from my experience I have found it most difficult to use any one as a definitive measure of the actual pathology involved (Slide 128).

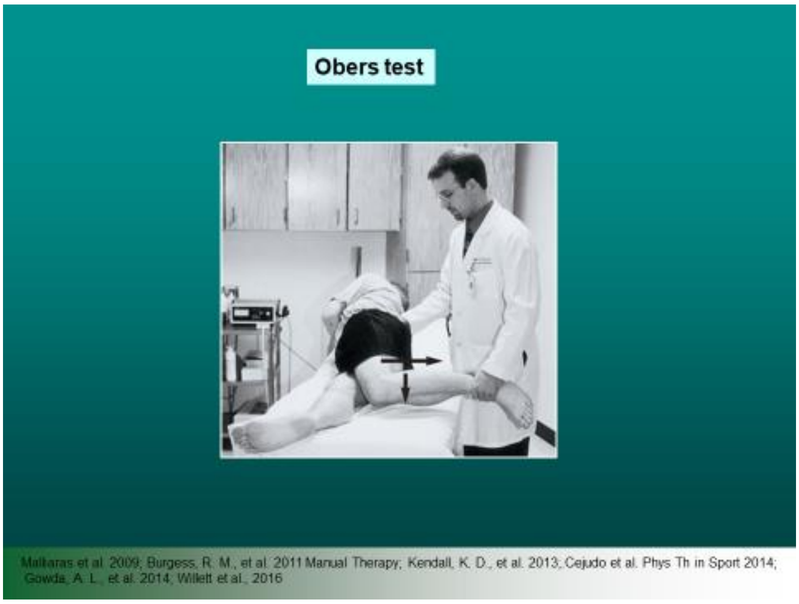
5e ii. Leg Length Deficiency (LLD)

Leg length discrepancy (LLD) has been a controversial issue among researchers and clinicians for many years. True LLD and functional LLD i.e. the structural and functional LLD, need to be tested, as undertaken by Khamis and Carmeli, 2017, where they found a significant relationship between anatomic LLD and gait deviation. In clinical practice there are methods for measuring LLD. A fairly accurate method of testing utilizes a tape measure between various anatomical landmarks – the anterior superior iliac spine and the lateral malleolus of the fibula (Woerman et al., 1984). Although this test is frequently undertaken, due to the structural and postural differences when analysing the tape measure reading, it has been shown that standing radiological imaging has the best outcome (Sabharwal et al., 2006). However, where imaging has a relatively high validity and reliability, these measurements are performed statically and might overlook the dynamic function of the subject. Other studies describing tests for LLD include Azizan al. (2018); Badii et al. (2014); Jamaluddin et al. (2011); Khamis et al. (2017); Sabharwal and Kumar (2008).

5e iii. OBER Test

The Ober test and the modified Ober test evaluates tight, contracted tensor fasciae latae and the iliotibial band (Ferber et al., 2010; Gajdosik et al., 2003; Reese and Bandy, 2003).

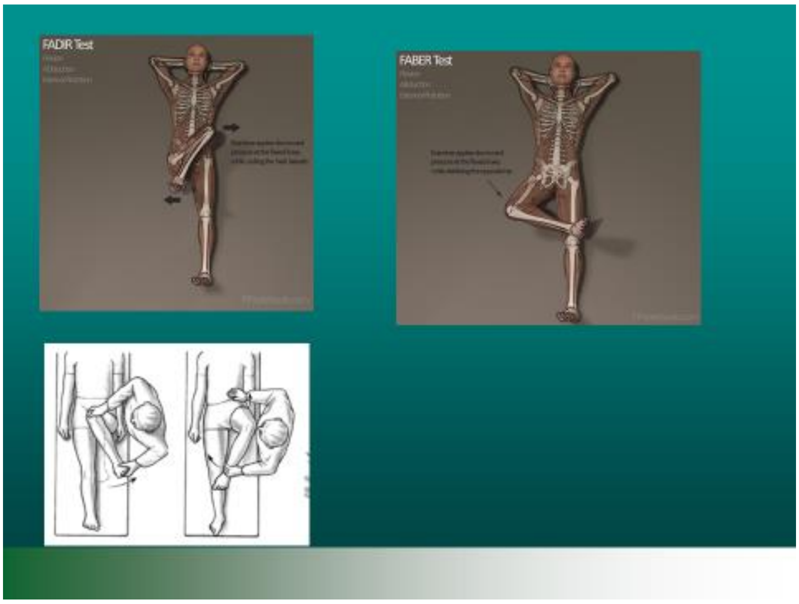
Slide 129



Although this test has been used by clinicians over the past years, a study by Willett et al. (2016) suggests that the Ober test assesses tightness of structures proximal to the hip joint, such as the Gluteus Medius and Gluteus Minimus muscles and the hip joint capsule, rather than the Iliotibial Band (Slide 129).

5e iv. FABER Test

Slide 130



A frequently used test for hip conditions is the Flexion, Abduction and External Rotation Test (FABER) or sometimes referred to as the Patrick Test (Slide 130). The FABER test is typically used as a provocation special test to detect hip, lumbar spine, or sacroiliac joint pathology, but has also been used as a measurement of combined hip range of motion. It is thought that limited range of motion with this measurement may be indicative of hip pathology. Positive FABER test was found in 19 healthy participants (Bagwell et al., 2016) and also in the study with fifty subjects referred for intra-articular hip injection under fluoroscopic guidance (Maslowski et al., 2010). According to Thomas Byrd (2007) the FABER test has been described both for stressing the sacro-iliac joint and for isolating symptoms to the hip. One should take into cognisance that the interpretation of the FABER test can be difficult, as the position adopted tensions the hip joint capsule, as well as the Ilio Psoas tendon and the anterior sacroiliac ligaments (Atkins et al., 2010). Trindade et al. (2018) demonstrated that the FABER distance test is correlated with the alpha angle and is a good diagnostic exam for pathological cam-type FAI as defined by alpha angle equal to or greater than 78°.

5e v. FADIR Test

Slide 131

Slide 131 shows the Flexion Adduction Internal Rotation (FADIR) test which is a sensitive manoeuver that may elicit symptoms associated with subtle hip pathology. This test (also known as FAIR test) is often referred to as an “impingement test” and may be associated with hip morphology as the combination motions of FADIR may cause an abutment between the femoral head and anterior acetabulum.

Differences in the value of the FADIR test have been reported by Kuhlman and Domb, (2009) – FADIR **plus** radiography, magnetic resonance arthrography (MRA), and injection of local anaesthetic into the hip joint to confirm the diagnosis and Byrd (2010) - virtually any irritable hip, regardless of the cause, will be uncomfortable with this manoeuvre. Thus, although the test is quite sensitive, it is not necessarily specific for impingement (Czuppon et al., 2016 – male versus female differences in outcome).

What is most important is to determine if this manoeuvre reproduces the current presenting symptom of the athlete and to compare both sides. A study of sub-elite football players with hip-related groin pain and a positive FADIR test exhibited distinct biomechanical differences compared with the asymptomatic side (King et al., 2018).

5e vi. C Sign

Slide 132

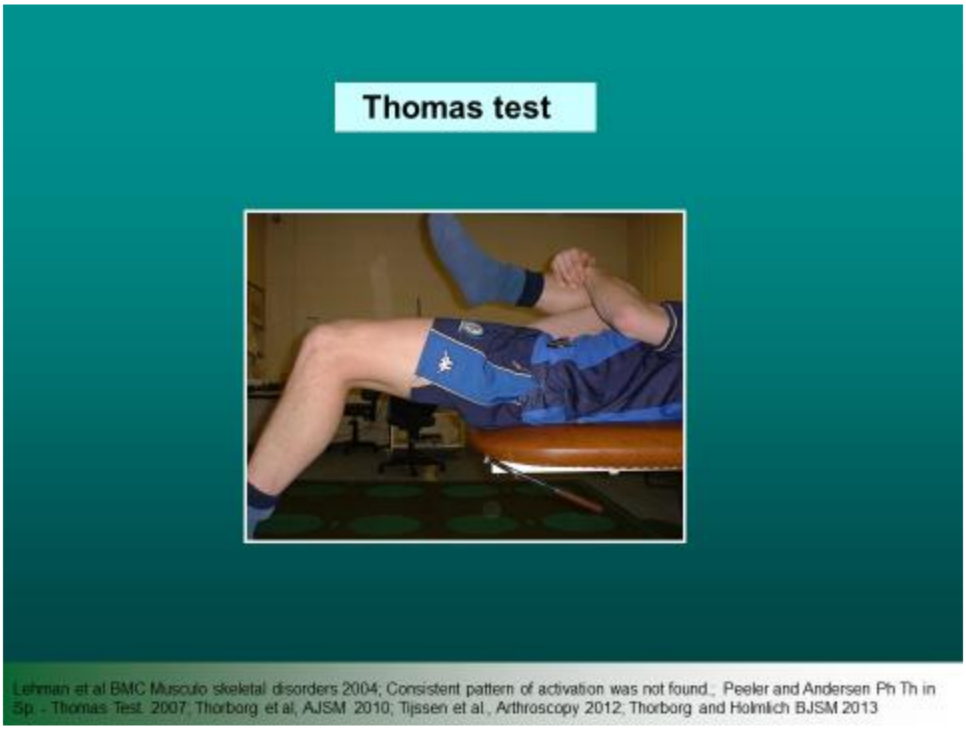
Patients with pain in the groin or hip often point to the area of pain by cupping the thumb and index finger in the shape of the letter C (Slide 132). This is usually an important indicator that there is a problem with the hip joint. Many studies incorporate the C sign into their battery of tests although there is no evidence as to the specificity of this test (Byrd, 2010; Wilson and Furukawa, 2014).

5e vii. LEG ROLL Test

Although there are minimal studies to verify the leg roll test, it provides valuable insight clinically for hip pain. This has been hypothesised to be as the result of the log rolling moving only the femoral head in relation to the acetabulum and the surrounding capsule with no significant excursion or stress on myotendinous structures or nerves. It is important to note that absence of a positive log roll test does not preclude the hip as a source of symptoms, but its presence greatly raises the suspicion (Byrd, 2010).

5e viii. Thomas Test

Slide 133



The Thomas test and Modified Thomas Test are used on most patients to assess tightness of hip flexion tightness, rectus femoris and abductors (particularly tensor fascia latae and Iliotibial band) (Slide 133). Tightness of these muscles are theorized to alter antagonist muscle function through reciprocal inhibition and synergistic dominance mechanisms which may result in altered movement patterns and increased risk of groin and hip injuries, as well as other lower extremity injuries (Mills et al., 2015). Vigotsky et al. (2016) indicated that the Modified Thomas test was not a valid measure of hip extension unless pelvic tilt was controlled. Further, the potential effect of warm-up on results is a valid consideration. It is also important when performing the Thomas test to differentiate between soft tissue tightness and joint restriction. According to Beneck et al. (2018), clinical measurements of hip flexion exaggerated the range of motion in both sexes and the Modified Thomas test appeared to control for rotation of the pelvis during hip extension in men. However, in women, hip extension measurements were exaggerated. As the physiotherapist for the Super 14 Rugby team, I used the Thomas test on a daily basis on the forwards (and others) to identify significant muscle tightness. As a result, I was able to address these limitations using the Contract – Relax PNF technique. It was speculated that possible injuries due to these tight structures was decreased. Once again, I should have consulted research personnel to show this very positive outcome. The pity is that clinicians in the sports field are mostly too busy to interact with research people. If I had to re-visit my professional career, this is one of the changes I would make and definitely be more interactive with research personnel.

5e ix. Adductor Squeeze Tests (AST) / Adductor Tests

In 1999 Per Holmich stated that a major cause of long-standing problems in the groin was adductor-related groin pain. Decreased hip adductor strength is a known risk factor for groin injury in footballers (Crow et al., 2010, Engebretsen et al., 2010). As a sports clinician, the benefits of specific strengthening exercises of the adductor muscles has been accepted. This was proven to be the case with the Super 14 rugby team, the Premier League footballers and other sports, especially where kicking and changing direction is the norm, as I have shown in Chapter 3 on Anatomy.

Slide 134

Author	AST Test	Outcome
Coughlan, et al., 2014.	140 Elite junior rugby union players. The AST in 3 positions of hip flexion (0, 45, and 90 degrees).	The highest AST values were observed at **45 degrees of hip flexion Normative AST values in an elite junior rugby union population** were established Clinically, the sports medicine professional may use these results in making decisions on the management of both symptomatic and asymptomatic players.
Nevin and Delahunt, 2014	18 Gaelic football players with current longstanding groin pain (LSGP) and 18 matched injury-free controls	**Gaelic football players with LSGP exhibit decreased AST** values and **hip joint range of motion** when compared to non-injured players.
Hodgson et al., 2015	Using a sphygnamometer, AST scores were collected at one professional rugby club. 4 positions - hip flexion; 0°, 60° and then for the latter two tests both hip and knee flexion 90°:90° supported and 90°:90° unsupported	**Established references ranges for AST for normative pre-season** data in non-injured rugby players.
Light and Thorborg, 2016	20 elite level footballers (16-33 years) without previous or current groin pain were … Long-lever in abduction (… (Add) and short-lever in A…	All three tests described in this study are reliable methods of …r squeeze strength. However, the test performed … **position seems the most promising**
Wollin et al., 2017	22 elite youth football players. 5-second AST was captured daily using a hand-held dynamometer (HHD)	Player monitoring involving the **5-second AST** can be captured effectively and is suitable to include as part of **secondary injury prevention** during or immediately after a **congested tournament.**
Delahunt et al., 2017	55 male elite Gaelic football players	Provides preliminary evidence that **pre-season AST and HAGOS function**, sport and recreation subscale scores can be used to identify Gaelic football players **at risk of developing groin injury.**
Esteve et al., 2018	303 male soccer athletes. AST: (1) the **short-lever** (resistance placed between the knees and 45 of hip flexion) (2) the **long-lever** (resistance placed between the ankles and 0 of hip flexion)	**Preseason hip AST is lower in male soccer athletes who have had past-season groin pain for more than 6 weeks** compared with soccer athletes without past-season groin pain, independent of current groin pain status and age.
Wormer et al., 2019	333 Professional and Semiprofessional Male Ice Hockey Players. 5sec AST and completed the Sport subscale of the Copenhagen Hip and Groin Outcome Score (HAGOS). Bilateral Add and Abd strength was measured using HHD.	**Routine 5sec AST may allow the early identification of affected ice hockey players** and indicate yellow and red light situations, in which players may benefit from load management and appropriate hip muscle strengthening.

Many Tests

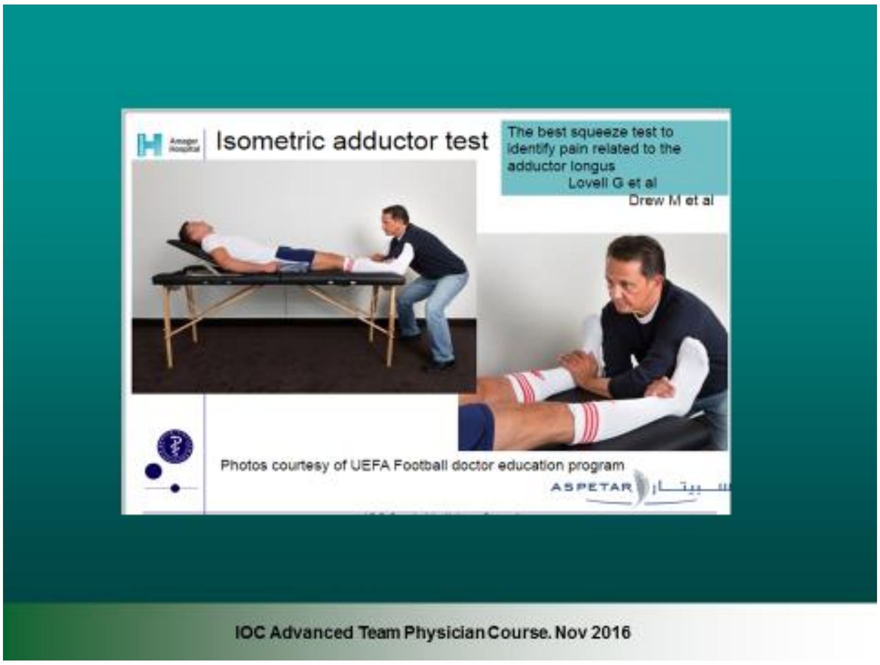
LSGP: Long Standing Groin Pain; HAGOS: The Copenhagen Hip and Groin Outcome Score.

Over these past years the value of strong adductors has been recognised and thus the Adductor Squeeze Test is used in most elite sport, including Premier League and many studies have been undertaken to show the validity of this test (Slide 134). The Adductor Squeeze Test is used in elite sport to show baseline strength when pre-screening an athlete (Delahunt et al., 2016) and as an ongoing test during the season to document any decreases in strength which could potentially result in hip or groin injury (Roe et al., 2016). Crow et al. (2010) concluded that the squeeze scores were reduced by 10% one week preceding groin injury in elite Australian Football League players. As a result, it is reasonable to suggest that weekly monitoring of adductor strength within a squad could identify those at risk of breakdown and allow early modification of activity. Having questioned many Premier League doctors as to their reasoning for using the Adductor Squeeze Test in spite of the fact that it was not related to a specific adductor muscle, the common response was that it definitely gave them an indication as to the potential groin/hip injury when they identified weakness or possible overload compared to the baseline. The Adductor Squeeze Test may also be helpful to gauge return to play readiness.

Slide 135

For the past years there has been debate as to which position is best for the Adductor Squeeze Test (Delahunt et al., 2011; Falvey et al., 2015; Light and Thorborg, 2016; Lovell et al., 2012). The consensus appears to be the crook lying position as demonstrated on Slide 135 which is used by most of the elite sports with which I am involved.

Slide 136



At the advanced team physician course (2016), Holmich demonstrated the Adductor Squeeze Test with the legs in extension (0 degrees), claiming that this was the best testing position (Slide

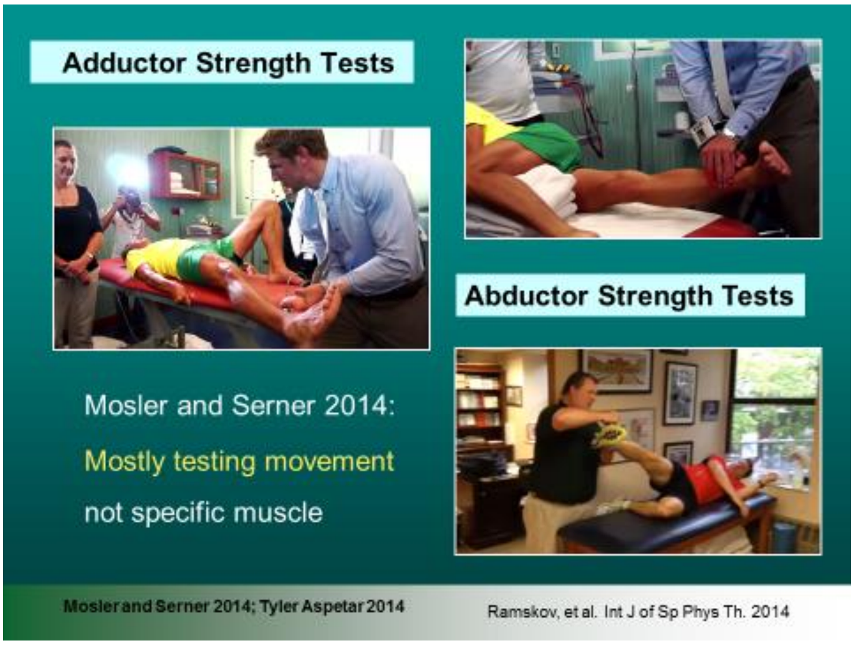
136). Currently, from my observation, the most commonly used tests are the 90 degrees and Holmich test in 0 degrees. However, to improve the specificity and post-test probability of diagnosis, the clinician may perform these tests with the combination of clinical (palpation) and radiological findings.

The Adductor Squeeze Test may also serve as a preliminary profile of 'normal' results in certain populations. However, an electromyography study does not allow for differentiation between the individual muscles of the adductor mass in the different testing positions. This would be useful in improving diagnostic accuracy of the clinical examination of groin pain. This research should also be repeated in various injury groups i.e. acute vs chronic. As stated previously, there will be different norms for different categories of athletes such as gender, different sports and specific position within the sport. Further research in this field is warranted before a definitive conclusion can be ascertained.

Slide 137

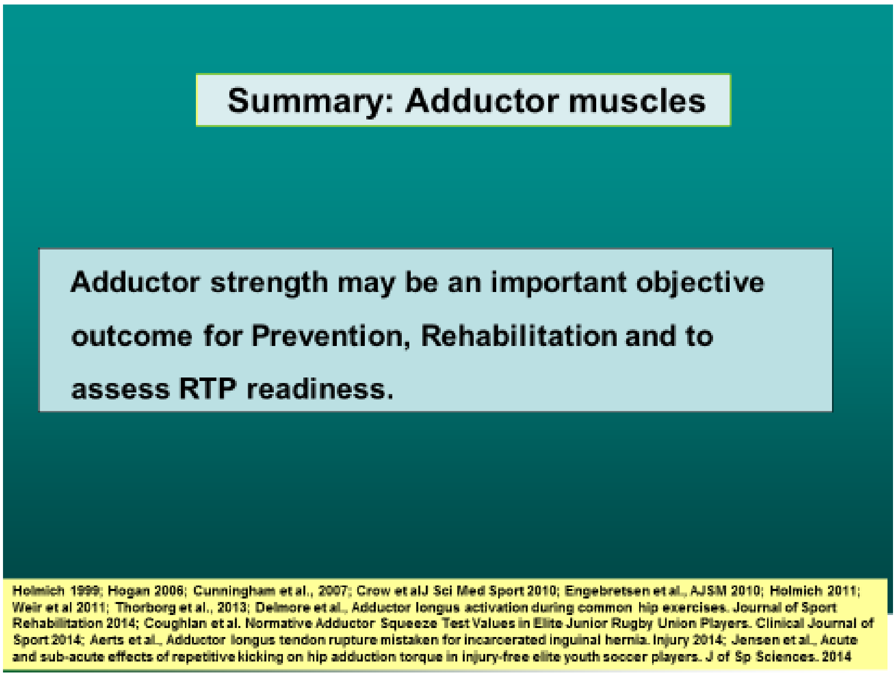
The Copenhagen five-second squeeze test is deemed to be a valid indicator of sports-related hip and groin function (Thorborg et al., 2016) and is currently very popular with most elite teams (Slide 137). In situations where football players report groin pain intensity of 6 or more on this test, a substantially impaired sports-related hip and groin function is indicated. It has been likened to a “traffic light” in the management of footballers with groin pain and it is used in most elite sports. I find this to be an easy test to perform and appears to have a positive outcome in my management. It has also been suggested that this test may be a promising research tool for future research. This Copenhagen five-second squeeze test was further validated in the study of ice hockey players and by indicating yellow and red light situations, they hypothesised that players may benefit from load management and appropriate hip muscle strengthening strategies (Worner et al., 2019).

Slide 138



As discussed by Mosler and Serner (2014), the tests for adductors are mostly testing movement and not a specific muscle and this must be taken into consideration when performing the tests (Slide 138).

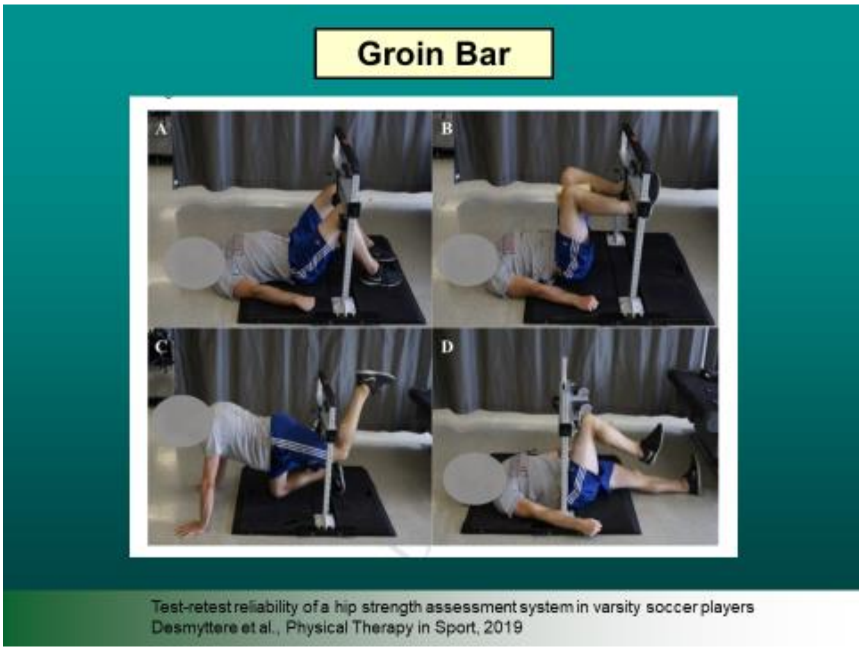
Slide 139



In conclusion, as discussed on Slide 139, it is an accepted fact that adductor strength is a clinical indicator used in both injury prevention and rehabilitation, and should be monitored in the athlete. It is interesting that to date studies are still attempting to find the best test for adductor muscle strength, as there is still no clearly defined test.

From my professional work including conferences I have attended over the past 10 years, it seems that the Adductor Squeeze Test in 45 degrees using a dynamometer and the Copenhagen five-second squeeze is performed by most of the Premier League Football clubs as a screening and a prevention strategy for groin and hip problems. This is often on a weekly basis and useful as a tool to monitor fatigue and potential groin and hip pathologies throughout the season.

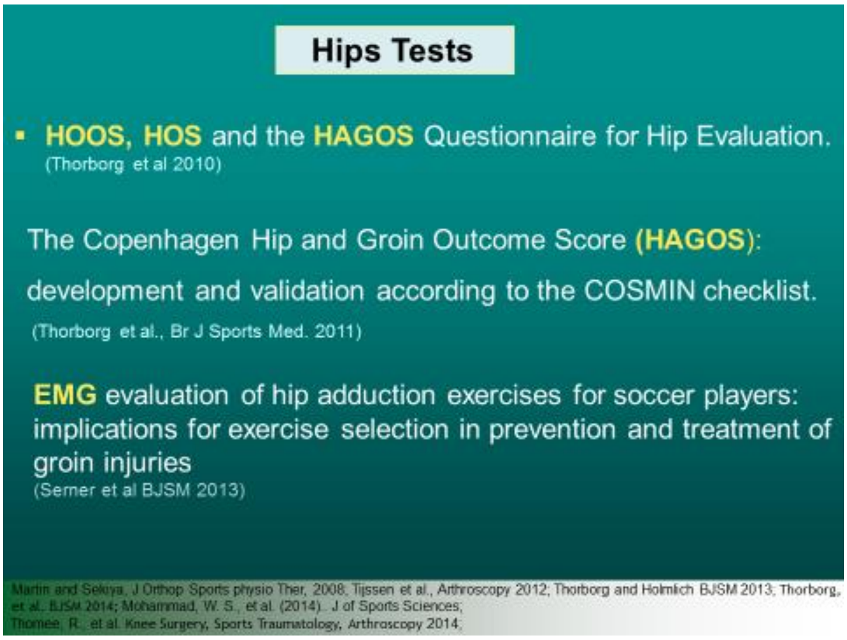
Slide 140



Interestingly, in April, 2019, I presented a Hip and Groin lecture at Crystal Palace Football Club and Bournemouth Football Club and they showed me a relatively new machine to assess adductor strength that these clubs which they are currently using with excellent effect, particularly as it is reliable and objective (O'Brien et al., 2019) (Slide 140). This may be most useful for a more objective approach to assess groin and hip injuries, as well as potential problems.

5e x. The Copenhagen Hip and Groin Score (HAGOS)

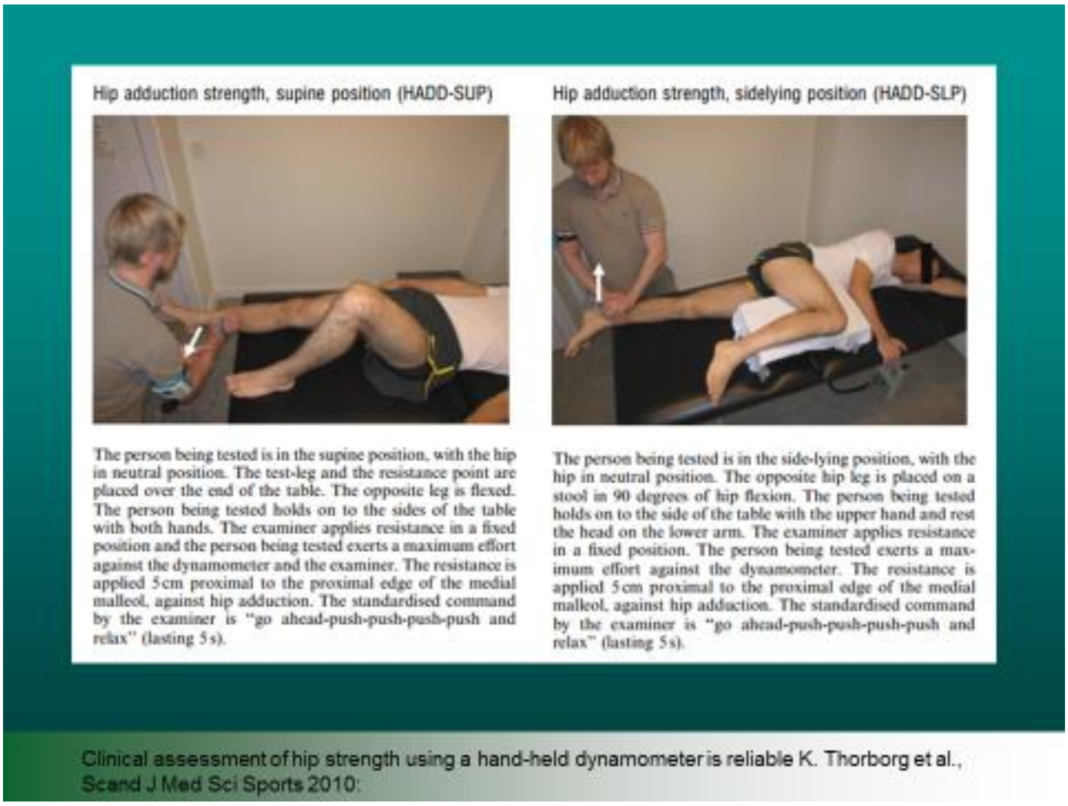
Slide 141



The Copenhagen Hip and Groin Score is a validated outcome measure (Slide 141). It is a six subset scale that asks questions about pain, stiffness, specific symptoms, limitations in certain physical movements and in activities of daily living and functional activities. It also highlights any restrictions in the level of participation and quality of life for the athlete. Studies that demonstrate the usefulness of The Copenhagen Hip and Groin Score protocol with good outcomes include Delahunt et al., 2016; Thomee et al., 2014; Thorborg et al., 2014, 2017 and 2018. These valuable outcomes include the evaluation of patients undergoing hip arthroscopy and also lower Copenhagen Hip and Groin Score subscales were noted in soccer players who have experienced hip and/or groin pain in the previous season compared with those who have not. Further, this test can be used both for research and in the clinical setting at individual and group level. I have only used this protocol in these past few years and found it to be most effective. Hence sharing this with my colleagues is most meaningful.

5e. xi Hand-Held Dynamometer - HHD

Slide 142



Slide 142 demonstrates the hand-held dynamometer which has been used by many clinicians over the past years. A few studies have demonstrated the validity of this test (Fulcher et al., 2010; Hanna et al., 2010; Mosler et al., 2017; Stark et al., 2011; Thorborg et al., 2010; Thorborg et al., 2013; Wollin et al., 2017). These authors concluded that this procedure is perfectly suited for the evaluation and monitoring of athletes and would assist assessment and management of an athlete's return to play following injury. Although the hand-held dynamometer is a promising tool for obtaining reliable hip strength measurements in the clinical setting, inter-tester reliability has been questioned (Thorborg et al., 2013). This is especially so in situations where athletes exhibit differences in upper-extremity muscle strength i.e. male vs female. However, if one requires a more objective measurement, this tool is more objective and specific compared to the manual squeeze test.

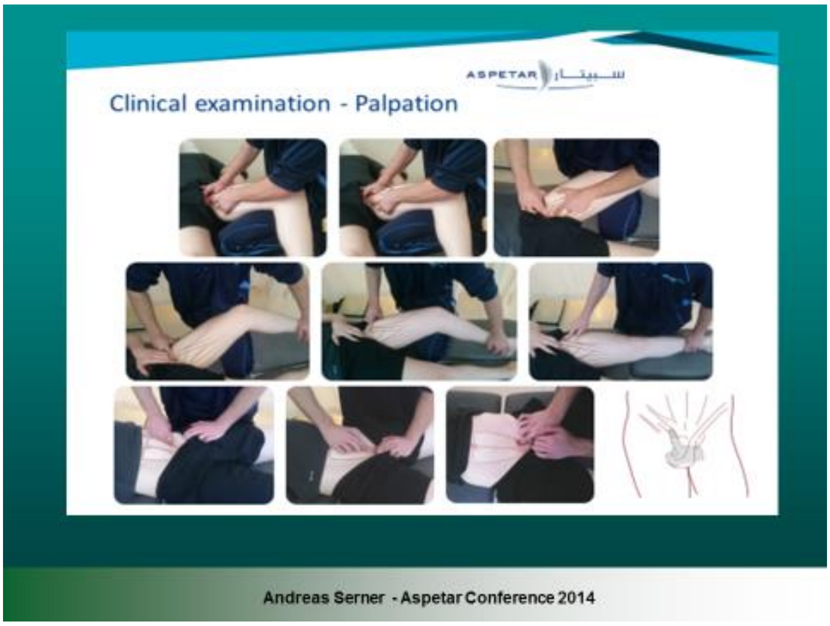
5e xii. Endurance Plank Test; Ligamentum Teres Tests

Slide 143

The sport-specific endurance plank test has been shown to be a valid, reliable and practical method for assessing global core muscle endurance in athletes (Tong et al., 2014). The Ligamentum Teres Test was shown to be an effective way of assessing the presence of Ligamentum Teres tears with moderate to high inter-observer reliability. In addition to an Ligamentum Teres tear, the presence of a pincer lesion or labral tear requiring repair are also associated with a positive Ligamentum Teres Test result (O’ Donnell et al., 2014). I do not use the Ligamentus Teres test, as I personally cannot conclude that the Ligamentum Teres specifically is the problem. However, the forward and side plank can be useful to observe strength of certain areas e.g. core muscles. These tests should be considered with a battery of other tests, as they are not specific (Slide 143).

5e xiii. Palpation

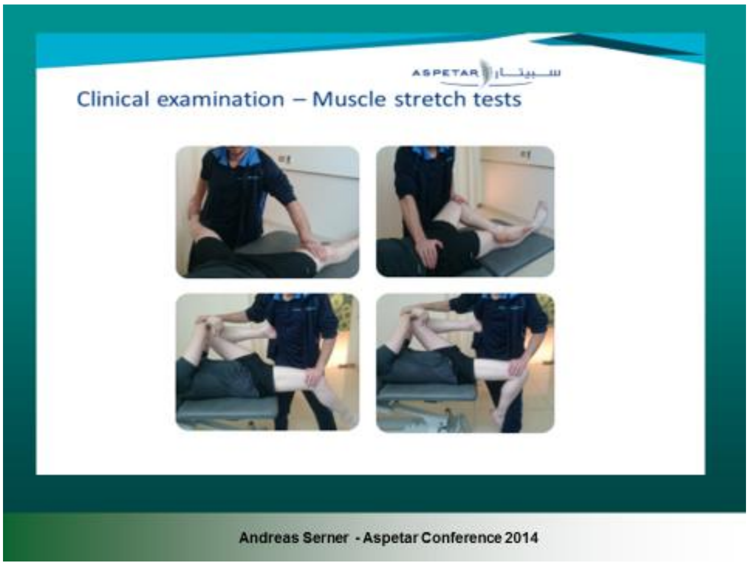
Slide 144



At the Aspetar conference (2014), Serner discussed the importance of palpation in conjunction with other specific tests (Slide 144). This was agreed by Serner et al. (2016) and Professor Holmich at the IOC Advanced team physician Course (2016).

5e xiv. Muscle Flexibility Tests

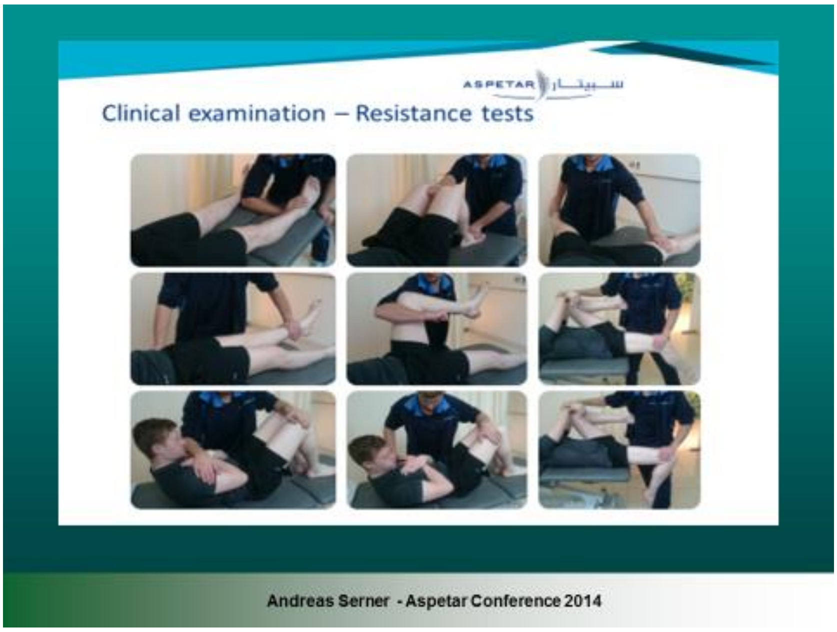
Slide 145



Muscle stretch tests were described at the Aspetar Groin Conference (Doha, Qatar, 2014). In particular, the adductor muscle stretch and the Thomas test (Slide 145). These two may be important in terms of prevention of injuries, as tightness of the Adductors and / or the Ilio-Psoas, Rectus Femoris or Abductors changes the biomechanics and thus may have an effect on potential groin or hip injuries. However, the clinician should be cautious regarding the different stretching tests and the timing of them, as the tightness may be dependent on pre or post activity. I personally test the flexibility of these muscles on an ongoing basis and integrate the specific test with functional tests such as wall running. Further, the tests that I undertake are timed at the same time i.e. either pre or post training, or a certain time each day. This appears to have a more valid outcome that can be managed accordingly. Further research is required to validate these practical findings.

5e xv. Muscle Resistance Tests

Slide 146



At the same Conference (Doha, Qatar, 2014), Serner, when discussing the prediction of MRI injury location using clinical examination, discussed resistance tests evaluating muscle strength against manual resistance (Slide 146). From my professional point of view, these tests are most important as they subjectively give an ongoing indication of the strength of each specific muscle. However, so often the actual strength for specific movements related to the sport is not undertaken e.g. flexion, adduction and inner range of motion for the kicking motion which I test pre-season and throughout the season. This is critical to prevent injuries and for rehabilitation and for full functional return to play.

5e xvi. Proprioceptive Neuromuscular Facilitation (PNF)

Slide 147

As Slide 147 demonstrates, a specific PNF test to mimic a particular sports activity is of utmost relevance. As I have alluded to previously (Chapter 3), in my work with all different sports I have found that a PNF technique (flexion / adduction and external rotation) performed on the player in order to assess the strength of the adductor muscles is very reliable. There is little evidence with regards to the use of PNF as an assessment test. However, I have been using it for many years as a preventative, management and return to play strategy with different athletes. Amongst other outcomes, the inner range of the adductors in hip flexion in this PNF test was shown to be very weak in the majority of the Super 14 rugby players with whom I worked from 2000 – 2006. Currently (2019) presenting to football coaches in the community, I observe this same weakness in the kicking action position. Thus, this neuromuscular pattern of movement appropriate for the specific function, requires attention, not only for stability and general strengthening of the adductor muscles, but specifically for the kicking action when required in specific sports. It shows that assessment in the functional range of the specific sport is essential to prevent injuries.

5f Observations from Specialist Clinicians.

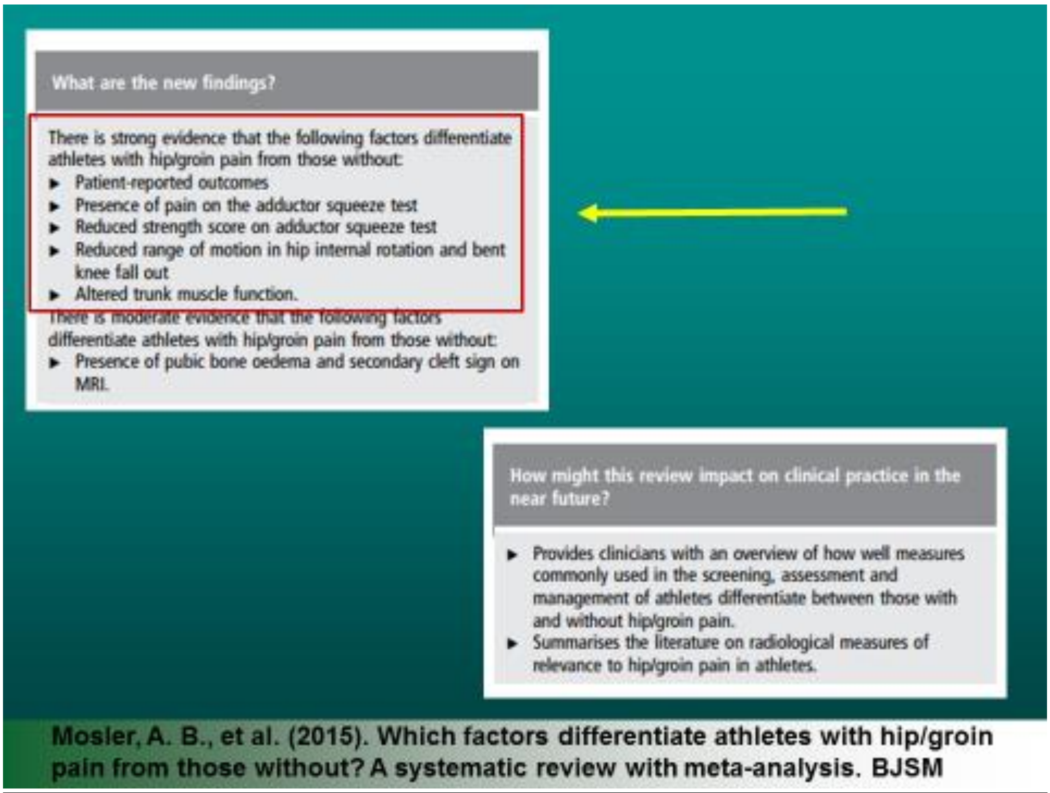
I have found great value in listening to some of the top International Specialists in the field of groin and hips and analysing their impression of the specific value of certain tests.

Slide 148

Wright (2016) stated that a fairly typical picture emerged with recurrent or chronic groin pain. Apart from the decreased strength with the Adductor Squeeze Test, the footballers often lacked internal rotation of the hip, had poor lumbar extension control and predictable movement dysfunction of the hip. He hypothesised that the common denominator was a weak inner range of hip flexion (Slide 148). This information coming from a football club where studies are being undertaken on groin and hip injuries and a constructive preventative strategy is currently taking place, merits recognition. Subsequently, I have been assessing and implementing these nuances where possible and finding these observations to be most productive. I thus share this with my colleagues when giving presentations.

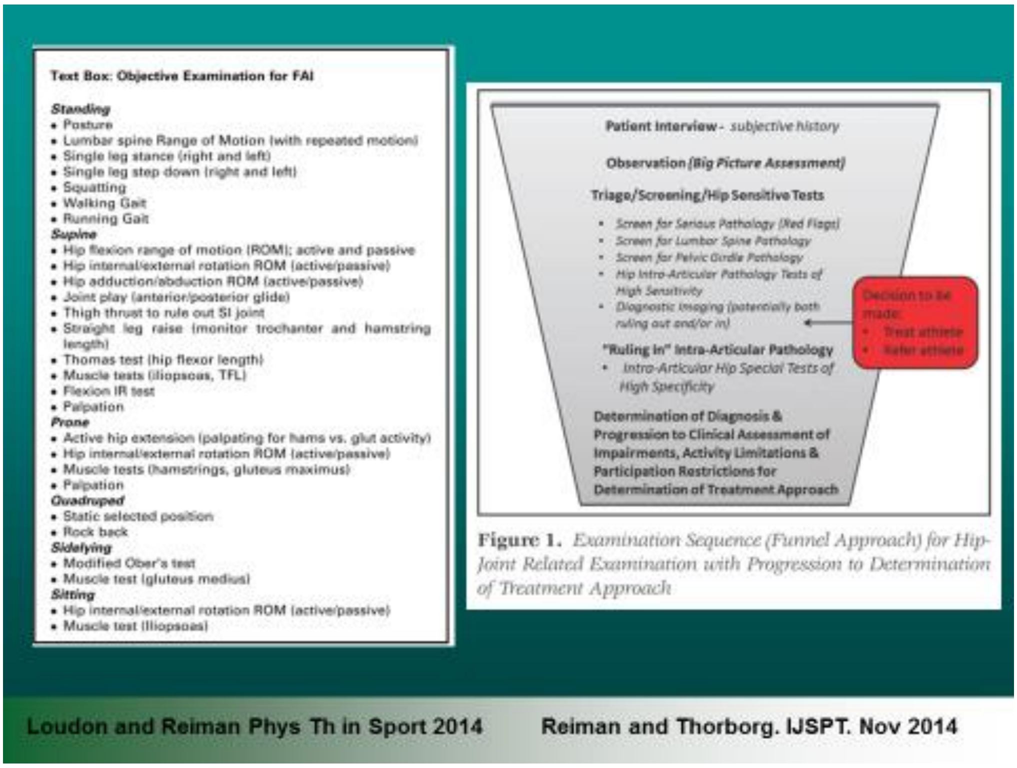
At the Aspetar Conference (Doha, Qatar, 2014), Andreas Serner demonstrated clinical examination techniques in athletes and attempted to explain the correlation of these with MRI injury location. This factor will be dealt with in more detail in the Radiographic section. Suffice is to say that they felt that adductor tests were best (resisted outer range, squeeze test and passive adductor test), in that there was an eighty percent probability of a positive MRI.

Slide 149



An important systematic review to see which factors differentiate athletes with hip/groin pain from those without was undertaken by Mosler et al. (2015). The outcome showed that patient reported outcome, pain and reduced strength on the Adductor Squeeze Test, reduced range of motion in internal rotation and bent knee fall out are the outcome measures that best differentiate athletes with hip/groin pain from those without this pain. Once again this shows that with regard to specific tests, a battery of tests is imperative when managing hip and groin pain. This is advised to be done with relevant radiological imaging (Slide 149).

Slide 150

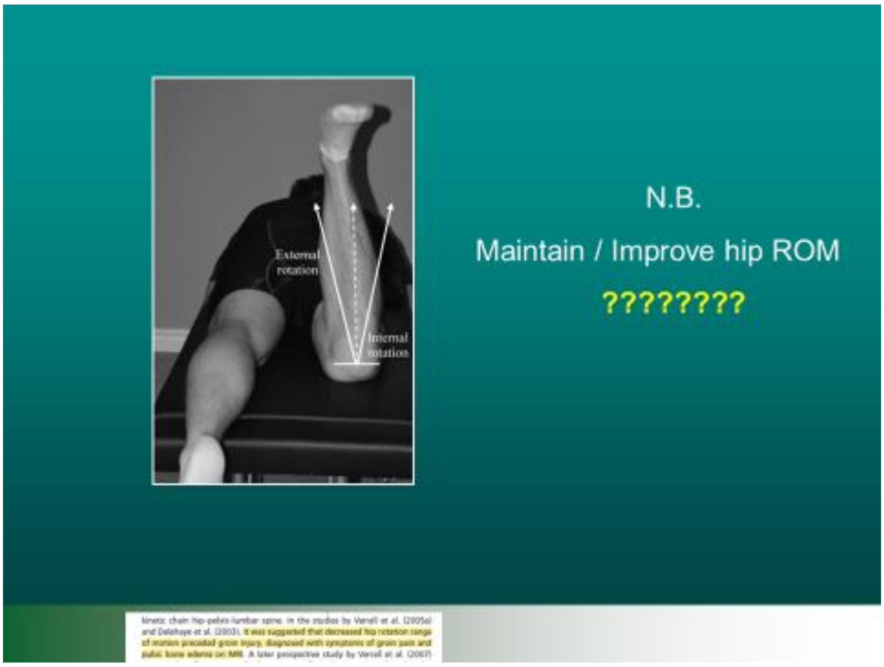


Two good studies that provided a structure and overview of all tests were that of Loudon and Reiman (2014) and Reiman and Thorborg (2014) (Slide 150). This structured approach for examining groin and hip problems may be helpful. The strengths and limitations of each component of these approaches vary from athlete to athlete. Thus these systematic, cogent, hip examination and assessment approaches should always be individualized to each particular athlete and situation. Therefore, in spite of these good studies, perhaps the clinicians can devise their own examination strategies based on their experience, the evidence based medicine and clinical reasoning.

When I give presentations or treat athletes, I always state that there is no set recipe, as not only are the athletes all individual, but the sport / position within the sports will have very different demands. I am continuously learning better testing techniques for specific pathologies. Above all, I have found that even without a definitive diagnosis for a groin or hip problem, functional testing and identifying maladaptation very often sorts out the initial groin pain. This is a key component to my approach of groin and hip problems. Further, specific hip tests are evolving for the better and a battery of specific tests in conjunction with certain functional tests, may add value to the final diagnosis. However, I continuously communicate with my colleagues who are experienced in this field, attend hip and groin conferences, as well as research all studies and attempt these to see the practical outcome. I feel it best to not blindly accept all the new research, but analyse thoroughly and react accordingly. Once a certain protocol is implemented into practice and I observe effective outcome, I share this with my colleagues in order to enrich their knowledge (as mine has been done since undertaking this thesis) and subsequent management of the groin and hip area.

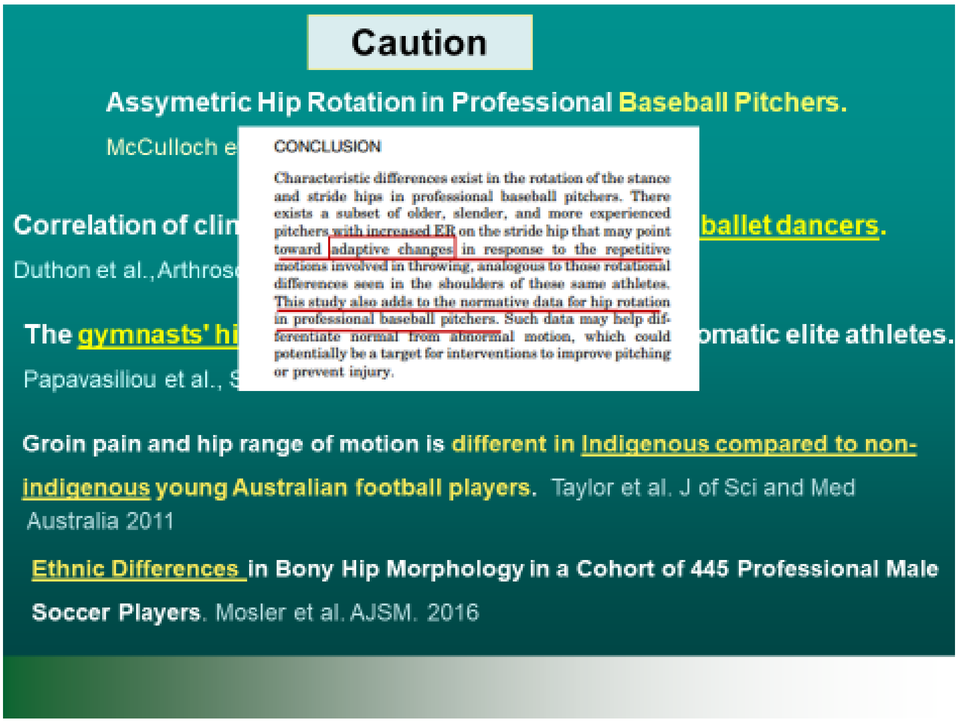
5g. Caution

Slide 151



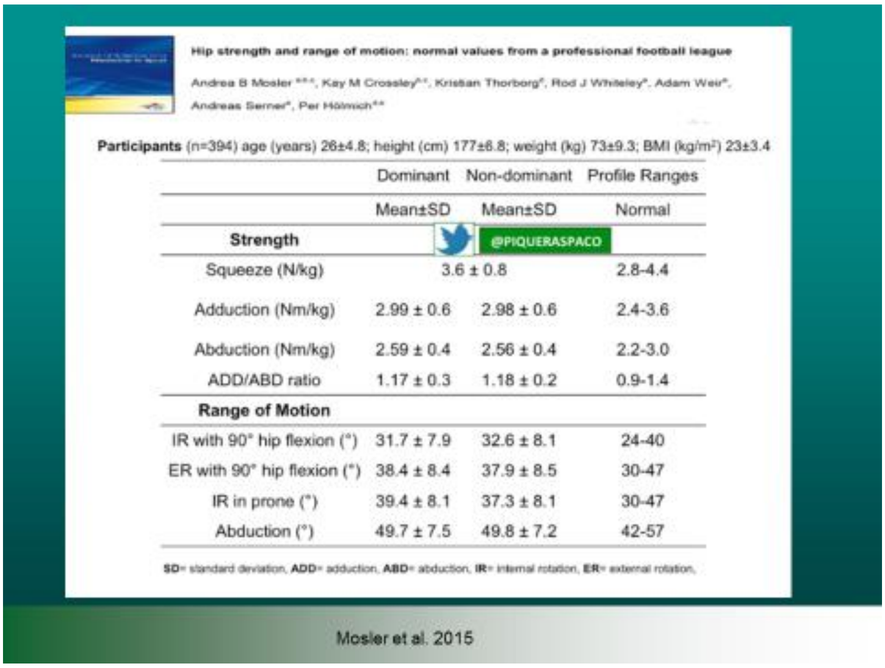
Many studies discuss hip and groin pain and relate it to decreased hip range of movement. As a physiotherapist dealing with groin and hip pain, one is taught to maintain full hip range of movement (Slide 151).

Slide 152



However, a critical factor that needs to be taken into account by all clinicians when testing hip pain, is that one needs a baseline for all the different activities. The different sports and adaptations of the hip to the specific sport must be taken into consideration. This variation in hip range of motion amongst different activities / sports has been shown in a number of studies (Elite female ballet dancers - Duthon et al. (2013); Professional ballet dancers - Kolo et al., 2013; Tennis players and Baseball players - Ellenbecker, et al. (2007); Baseball Players - Li et al. (2015); Gymnasts - Papavasiliou et al. (2014) and Australia dancers - Chan et al. (2018). Further, gender dependent differences in hip range of motion and impingement testing has also been shown in a study by Czuppon et al. (2016). In my presentations, I have been highlighting the fact that there is adaptation of the hips to certain movements being performed repeatedly in specific sports such as baseball, gymnastics etc. Further, there are ethnic differences which require consideration (Mosler et al., 2016; Taylor et al., 2011) (Slide 152).

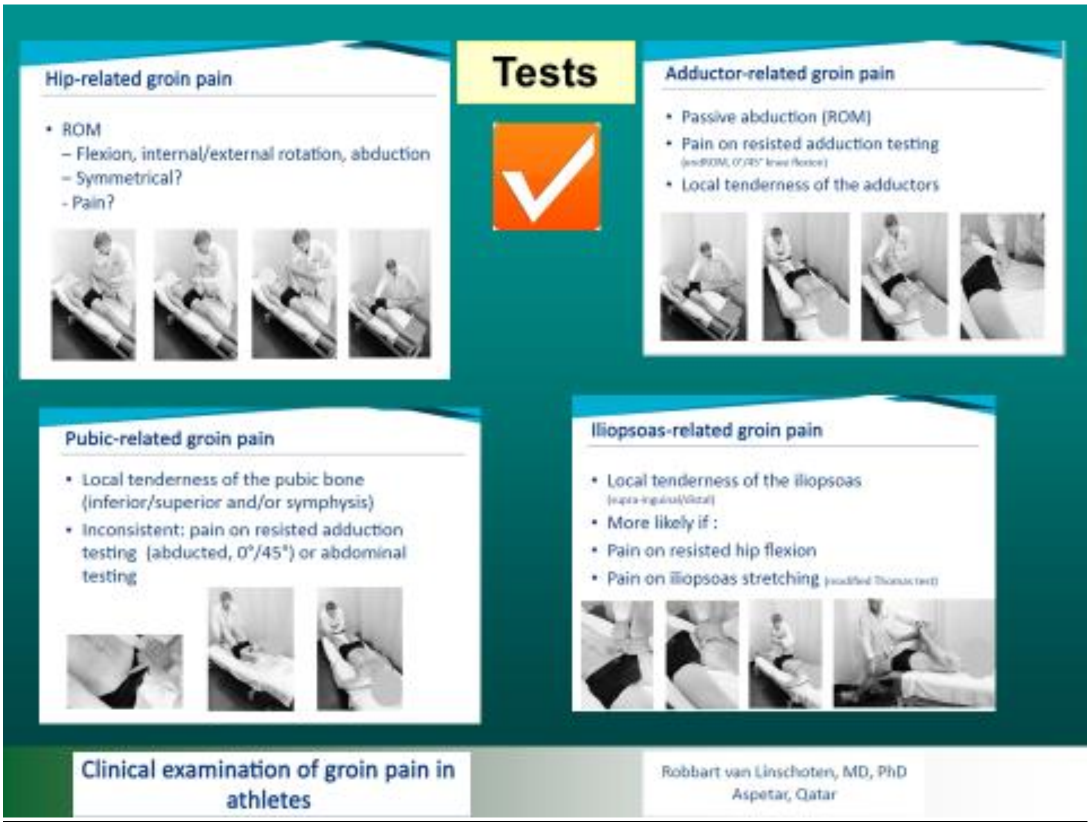
Slide 153



More studies are required showing normal values for hip strength and range of motion in different sports and thus giving basic guidelines for future reference for clinicians working in this field (Slide 153). Mosler et al. (2016), showed normal values for hip strength and range of motion that may be used as reference profiles in the clinical assessment, screening, and management of professional football players. They stated that leg dominance, recent past injury history and ethnicity do not need to be accounted for when using these profiles for comparison purposes. Thus normative data in different sports (and positions) would be most valuable for the management and particularly, the prevention of hip and groin injuries (Mosler et al., 2017).

5h. Solution - Functional and Specific Tests

Slide 154



Slide 155

Based on the Doha Agreement (2014) and the clinically based taxonomy to categorise anatomical areas, a useful overview for testing different pathologies as shown on Slides 154 and 155, has been adopted by many clinicians (Van Linschoten, 2014). My belief is that the way forward is to endeavour to explore this testing regime which is more structured than previously. However, I would not make this the absolute criteria for testing athletes, as I still believe in the value of functional testing in conjunction with these tests.

There are many functional and specific tests that are pertinent for prevention and management strategies for the groin and hip region. The specific tests can be useful but mostly lack specificity, whilst the functional tests demonstrate functional limitations which need to be addressed in treatment and may not provide a structural diagnosis. What is important, is to do a battery of most of the tests at all times and analyse the outcome of all tests which may give clearer insight to a diagnosis. As I stated previously, I think as clinicians, we should focus less on a specific diagnosis in complex hip and groin pain. It is very important to do the tests, noting all the mal-adaptations and biomechanical nuances in order to improve the treatment outcome.

Conclusion: Functional and Specific Tests

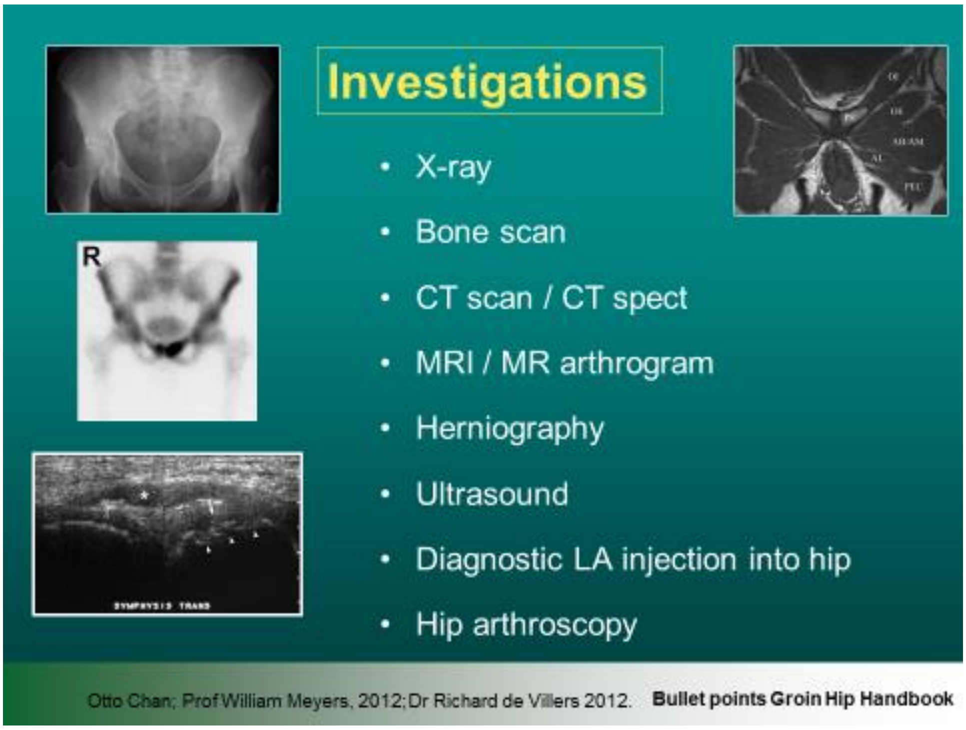
The presentation of multiple concurrent pathologies and lack of sensitivity of individual physical diagnostic tests has been described in a number of the studies, as shown above in this chapter. As overall there has been no proof of one particular definitive test for a particular diagnosis, excellent knowledge of all the evidence based medicine relating to functional and specific tests require observation on an ongoing basis. The clinician can then combine these with clinical reasoning and most importantly, collaborate with the specialists and other colleagues in this field. Further, clinical experience is of great value, as over the years and with different sports, I have noted clinicians who recognise patterns and devise strategies for groin and hip tests that have been successful. Unfortunately, these “anecdotal,” subjective tests (some of which I have structured myself) have not been researched and thus not reported and acknowledged. Identifying anatomical (especially functional anatomical) classification of pain, as opposed to specific injured structures may be the answer to a more valuable approach to assessment for groin and hip pain. Thus, although this is a complex area, I suggest that the clinician take note of all these tests and devise a management strategy based on a biomechanical assessment of the entire kinetic chain. Further, preventing these pathologies from occurring in the first place is the ideal solution with a thorough understanding of all these tests and also giving an assessment of each individual athlete related to his / her biomechanics and sport.

Chapter 6: Radiological Imaging

6a. Introduction

Radiological imaging has continued to evolve over the past 10 years. The importance of relating the anatomical, clinical and imaging findings is fundamental in the assessment of an injured athlete.

Slide 156

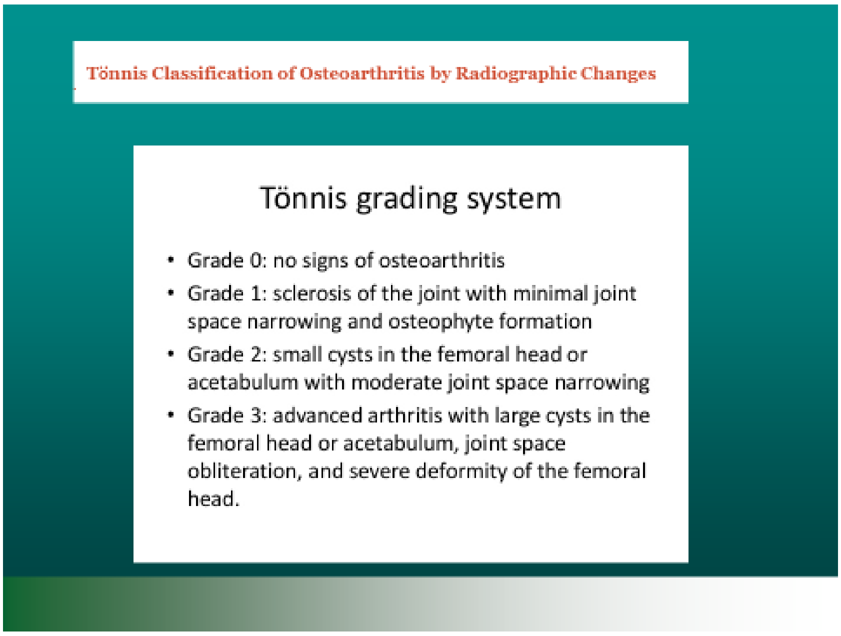


There are many different imaging protocols which are undertaken to explore different pathologies and there is ongoing discussion between specialists and researchers regarding the practical value of radiological imaging in diagnosing groin and hip pathologies (Slide 156).

Branci and Robinson (2014) stated that the interpretation of the existing radiological literature on long-standing groin pain in athletes remained a challenging task. Current evidence was based on relatively few studies of varying methodological quality. The studies were heterogeneous in terms of their design (included sports, ages and sexes of study participants) and only few of them document their clinical examination findings, thereby preventing an accurate classification of clinical entities and diagnoses affecting study participants. Moreover, the existing diagnostic terminology was confusing and characterised by a general lack of consensus regarding radiological definitions and diagnostic criteria. Thus radiological studies have suffered in terms of the nomenclature and potential referrer clinical bias. Despite this, the main imaging findings that correlated best with current symptoms of Long-Standing Groin Pain appeared to be subjectively assessed moderate to marked oedema of the Pubic Bone Marrow and para-symphyseal soft tissues or partial disruption of the soft tissues involving the anterior joint capsular, adductor and rectus abdominis tendons ('cleft'). They concluded that more studies were required to validate the presence and severity of such findings in symptomatic and asymptomatic soccer players. Further, future imaging studies require more structured and rigorous assessment of player examination and symptoms to determine if imaging can have a role in helping differentiate the many clinical entities described. This has subsequently been a work in progress over these past years and was somewhat improved by the Doha International Consensus Agreement (2014) whereby they claimed that the different anatomical entities may aid in more specifically targeted imaging.

Although many studies have demonstrated the value of MRI over the past years (Armfield et al., 2006; Khan et al., 2013; Mullens et al., 2012; Omar et al., 2008; Ozcakar and Utku, 2014; Palisch et al., 2013; Reurick et al., 2012; Slavotinek et al., 2005; Sofka and Pavlov, 2001; Zoga et al., 2008), various studies such as that by Branci et al. (2013) and Zoga et al. (2008) highlight the fact that although radiological findings seem to consistently appear, these are not necessarily connected to clinical signs. This is key to my approach in my professional practice.

<u>Slide 157</u>



Different methods have been used to classify osteoarthritis of the hip (Terjesen and Gunderson, 2012). The Tönnis classification has been widely accepted for grading hip arthritis and has been used over a number of years (Slide 157). However, Valera et al. (2016) concluded that the Tönnis classification was a poor method to assess early stages of hip osteoarthritis and the routine use in therapeutic decision-making for conservative hip surgery should be reconsidered. Currently, the discussion amongst practitioners involved with hip pain, is the importance of having a grading system for hip morphologies and the implications of development of Femora-Acetabular Impingement Syndrome (FAIS) and possibly OA.

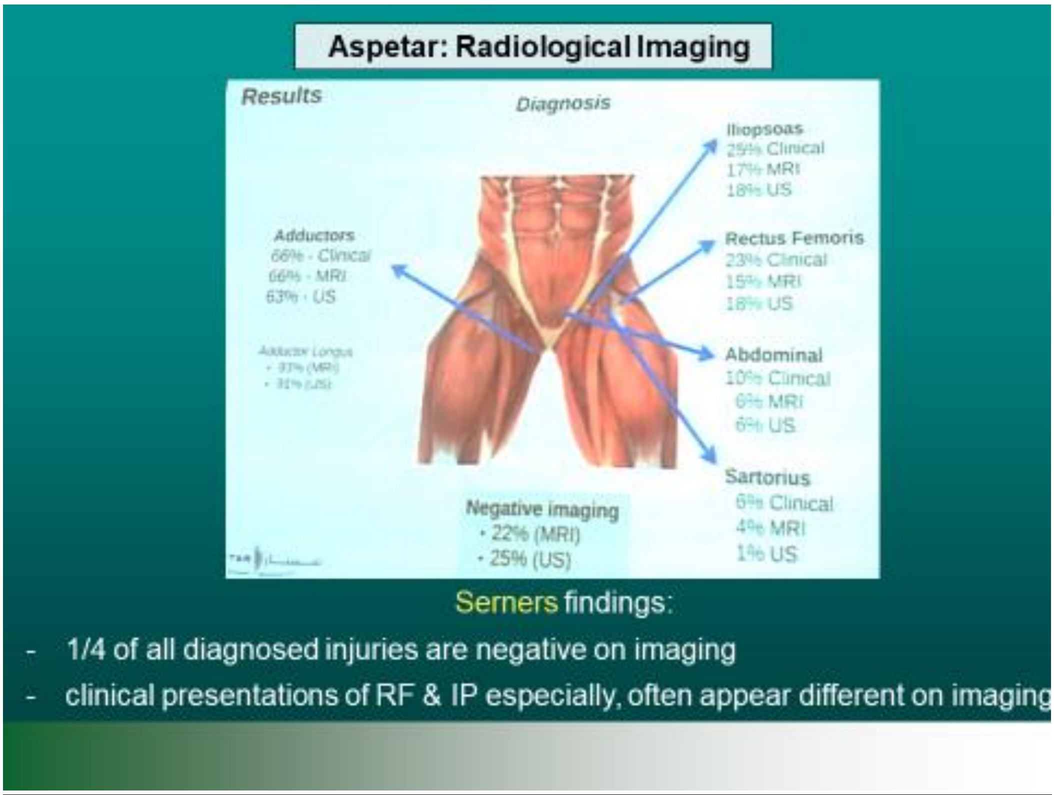
Table 7: Radiological Interventions

Author	Imaging	Outcome
Register et al. (2012).	MRI	**MRI** of **asymptomatic** participants **revealed abnormalities in 73% of hips, with labral tears being identified in 69% of the joints.**
Jung et al. (2013).	US and CTA	Investigated the sensitivity, specificity, and accuracy of **US** as well as the **CTA** findings and arthroscopic findings for the diagnosis of antero-superior acetabular tear and correlated tear types. The outcome was that **sonographic examination as a diagnostic technique was of limited use,** although **CTA showed reliable validity in the diagnosis of acetabular labral tears.**
Reiman et al. (2014).	MRI, CT and ultrasonography	**Acetabular labral tear was present in 22–55% of individuals with hip or groin pain** and can occur as a result of trauma or degeneration and are markedly associated with femoral acetabular morphological variations and may lead to biomechanical deficiencies. Thus imaging methods such as **MRI, CT and ultrasonography** have demonstrated **reasonable accuracy**, but **not at a level that allows use as a stand-alone measure.**
Ho et al. (2016).	MRI	Obtained predictive value of 3-T MRI in diagnosing grade 3 and 4 chondral lesions in the hip. They concluded that with a low positive predictive value, **MRI may be most useful in ruling out cartilage lesions.** Even though MRI showed increased sensitivity when identifying acetabular defects, once again the **study does not differentiate between symptomatic and asymptomatic hips.**
Madani and Robinson, (2019).	MRI	Detailed **clinical assessment** is necessary but remains challenging because of the nonspecific presentations. **Imaging**, and in particular MRI, plays an essential role in the evaluation process. But **only when the two are used in combination** can an accurate diagnosis be reached because several studies in asymptomatic athletes show that reactive changes are common.

CTA: Computed Tomography Arthrography; MRI: Magnetic Resonance Imaging; US: Ultrasound

A few Radiological interventions are discussed in Table 7 and demonstrate high abnormalities in over 50% of the footballers, which may or may not be symptomatic. In my experience with the Premier League Football, as well as many other elite sports, the value of ongoing research to see when the asymptomatic pathologies found on radiological imaging become symptomatic and the long term consequences of these findings would be most useful. With all the pre-signing and screening of Premier League football players, the incidence of asymptomatic acetabular labral tears and chondral lesions shown on imaging is very high. What the long term implications are and what management strategies should be undertaken with the players with these lesions, albeit asymptomatic, needs to be further explored. Importantly, the value of these findings during screening with regards to a player's future career requires careful consideration. I believe that undertaking a strengthening protocol for all the footballers, and particularly those with any abnormalities within the hip, is a pre-requisite for all management and particularly the prevention of asymptomatic morphological changes becoming symptomatic.

<u>Slide 158</u>

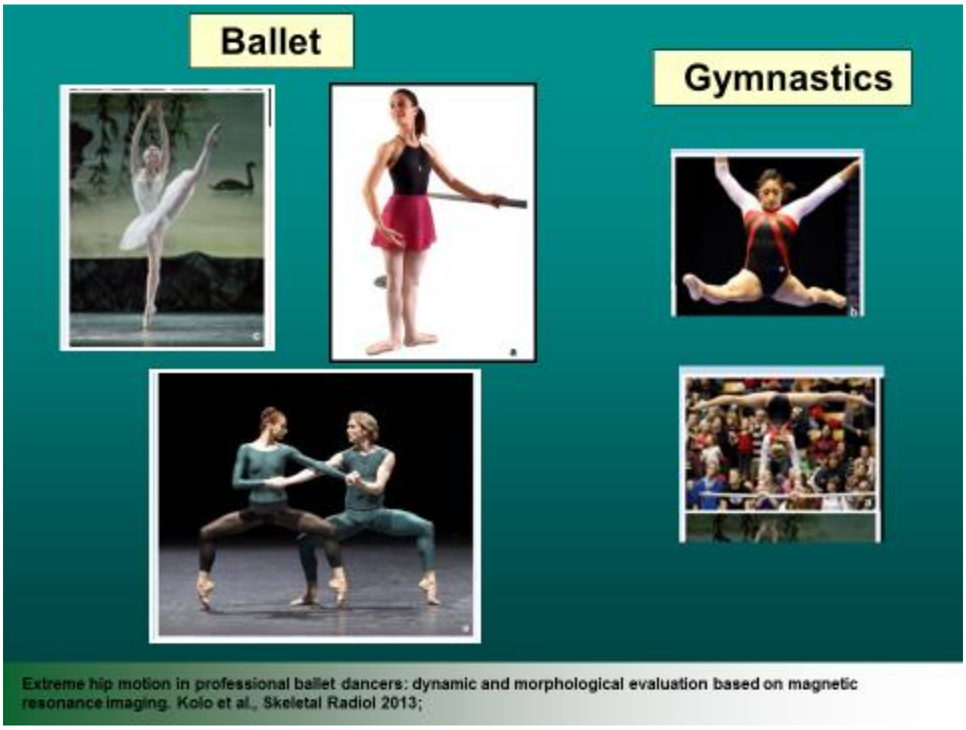


A presentation at the Aspetar Conference (Doha, Qatar, 2014), was given by Serner who broke down the different anatomical areas and explained the relevance of imaging in diagnosis (Slide 158). One quarter of all diagnosed injuries were negative on imaging. False negatives and false positives are areas of concern and need to be analysed for management and not assume that the negative imaging means that there is no problem in that particular structure, which I have seen to be the case occasionally in sports practice. Thus imaging should be undertaken in conjunction with sound clinical examination (including relevant tests and palpation), and should include past and present history.

6b. Radiological Implications on the Hip joint in different Sports

Various sports have different loads on the hip joint which may become pathological and are frequently identified on radiological imaging.

Slide 159



One needs to take cognisance of the different sports and the effect on the bony morphology of the hip joint (Slide 159). From my work with many different sports and recreational activities, I have found that the two most challenging sports / performing arts on the groin and hip region are gymnastics and ballet.

Table 8 - Different Sports and Implications on the Hip Joint

Sport	Author	Outcome
1. Gymnastics	Papavasiliou et al. (2014)	**Elite gymnasts** share four common morphological characteristics on **MRI** that **deviate from normal** and are considered to be the result of **adaptational changes** relevant to the specific sport
2. Ballet	Duthon et al.	**Repetitive extreme movements can cause femoral head subluxations and**

	(2013)	**femoro-acetabular abutments** in female ballet dancers with normal hip morphological features. Pathologic changes seen on **MRI were symptomatic in less than two thirds of the dancers**
2. Ballet	Harris et al. (2016).	In a professional ballet company, **a high prevalence of radiographic abnormalities was found, including cam and pincer deformity and dysplasia**. The results also revealed several sex-related differences of these abnormalities in this population e.g. greater prevalence of CAM morphology in male (48% and 57% subjects) versus female dancers (8% hips and 12% subjects).
3. Soccer	Gerhardt et al. (2012).	The prevalence of **radiographic hip abnormalities in elite soccer athletes is common, particularly in young male athletes.**
3. Soccer	Branci et al. (2015).	Up to 71% of male asymptomatic soccer players displayed different **positive MRI findings** and **asymptomatic soccer players had significantly increased risk for BMO, adductor tendinopathy and degenerative changes than non-soccer players.** Moreover, **positive MRI findings were significantly more frequent in soccer players compared with non-soccer players irrespective of symptoms**, suggesting that these MRI changes may be associated with soccer play itself rather than clinical symptoms.
4. National Football League	Domb et al. (2014).	This study demonstrated a **high incidence of intra-articular pathologic lesions in a younger, retired National Football League** player cohort evaluated for persistent hip pain with the use of **MRI.** The majority of players had bilateral hip pain. The most **common finding was chondral lesions, followed by labral tears**. However, because of improved imaging and increased knowledge, physicians are attributing unexplained hip pain to intra-articular lesions with increasing frequency. Once again, the dilemma remains as to the cause and effect of these identified lesions picked up on radiological examination.
5. Hockey	Silvis et al. (2011).	In the study of asymptomatic collegiate and professional hockey players, the MRI findings of common adductor–abdominal rectus dysfunction were observed in 14 of 39 participants (36%) and hip pathologic changes in 25 of 39 (64%). Overall, 30 of 39 **(77%) asymptomatic hockey players demonstrated MRI findings of hip or groin pathologic abnormalities.**
5. Hockey	Gallo et al. (2014).	Identified the **common occurrence of asymptomatic hip and groin pathology shown on MRI** in professional hockey players. **This pathology did not produce symptoms or result in missed games within 4 years in most players after the MRI.**
6. Rugby	Farrell et al. (2016).	In a study related to elite academy rugby union players, it was shown that there was **95% prevalence of abnormality on hip MRI.** The percentage reporting symptoms was lower than 65% of the cohort although this was significantly higher than (non-rugby) matched controls at 15% of participants**. Rugby players demonstrated significantly reduced range of motion of the hip compared to controls.**
Rugby and Ballet	Blankenstein et al. (2020).	Investigated hip MRI findings in **asymptomatic professional male rugby players and male ballet dancers** compared to age-matched controls. Despite the difference in type of activity between groups, there were **equally high rates of labral tears and acetabular cartilage loss, questioning the role that sport plays in the development of these findings and their relationship to symptoms.**

MRI: Magnetic Resonance Imaging; BMO: Bone Marrow Oedema.

As the Table 8 clearly demonstrates, given the high prevalence of MRI findings in asymptomatic athletes, it is necessary to cautiously interpret the significance of these findings in association with clinical presentation. As stated in the table, the fact that there is a prevalence of radiographic hip abnormalities in young male athletes needs to be addressed due to the possibilities of leading to further pathologies around the hip (Gerhardt et al., 2012). Gerhardt et al. (2012) also emphasized that a clearer definition of the pathogenetics, pathomechanics and the natural history of these injuries would add to the knowledge base to eventually culminate in the creation of an optimal screening and prevention program for the protection of athletes of all ages across a multitude of sports. However, the challenge remains as to the imaging of this morphology and the relevance of the consequential symptomatic pathology and thus the management thereof.

6c. Pertinent Radiological findings in the Hip and Groin

6c. i. Pubic Bone Stress

Table 9 - Pubic Bone Stress

Author	Imaging	Outcome
Major, (2000).	CT, MRI, or technetium bone scintigraphy	**Athletes who complain of pubic symphysis pain, sciatica, groin pain, or a combination of these** often **require** not only conventional radiography **but additional imaging** using CT, MRI, or technetium bone scintigraphy to **identify associated pathology**. **Associated pathology can occur due to abnormal stresses across the pelvic ring that can lead to a secondary abnormality in the pelvic ring**. However, associated abnormalities in the sacroiliac or sacrum **are not always seen on conventional radiography**
Lovell et al. (2006).	MRI	**Substantial amounts of BMO at the pubic symphysis can occur in asymptomatic elite junior soccer players**, but it is only weakly related to the development of osteitis pubis.
Paajanen et al. (2011).	MRI	Attempted to **develop a grading system to demonstrate the effects of heavy training in contact sports on MRI findings in the pubic region**. Their grading of the BMO was **not necessarily related to the development of clinical Osteitis Pubis**. It was described as pubic bone stress injury occurring usually as a result of chronic overuse injury.
Brandon et al. (2011).	Ultrasound	Ultrasound can image tendinopathies and with its dynamic capabilities **can show true hernia formation at multiple sites in the groin**
Branco et al. (2015).	MRI	**Professional soccer players are at a higher risk of developing changes in the pubic region**, shown on MRI, compared with sedentary individuals. These findings are not necessarily caused by groin pain, and are probably **related to intense exertion.**

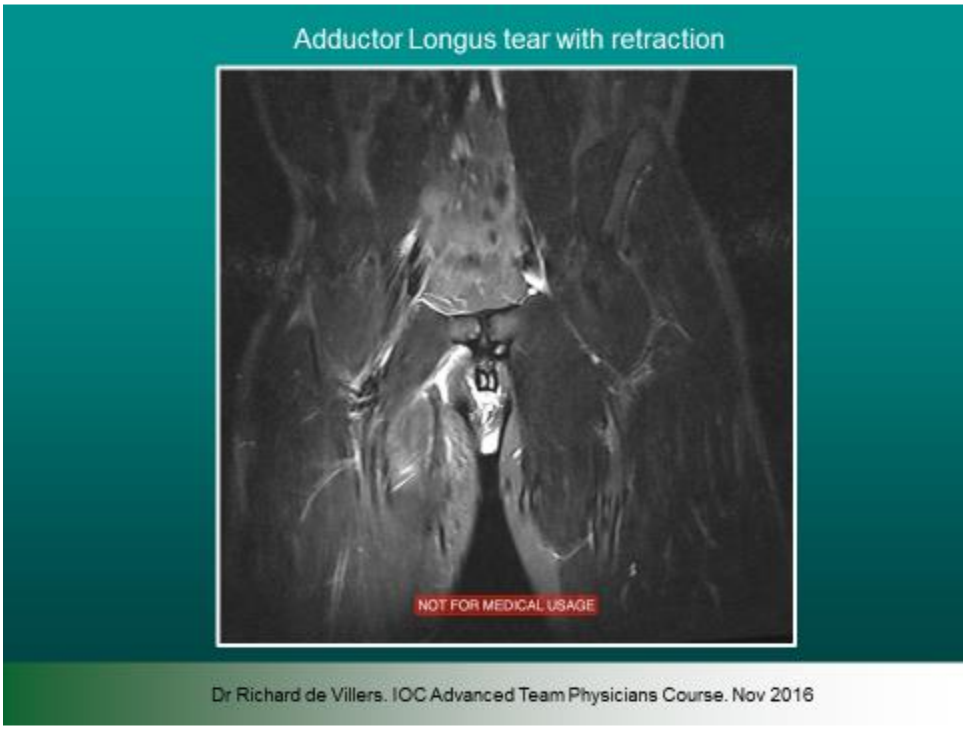
Robinson et al. (2015).	MRI and US	**Pubic bone marrow and parasymphyseal findings** (cleft, capsule/tendon oedema) on MRI or inguinal canal ballooning on ultrasound were **frequently found in asymptomatic athletes and did not predict injury or symptom development**
Todeschini et al. (2019).	US and MRI	**The evaluation of athletic pubalgia should be performed with radiography, US, and MRI.** High BMI, muscle injuries and osteophytes are findings associated with pubalgia. **US has low sensitivity** to detect injuries of the common aponeurosis of the rectus abdominis/adductor longus muscles.

BMO: Bone Marrow Oedema; US: Ultrasound CT: Computerized Tomography;

BMI: Body Mass Index

As has been discussed in Chapter 3 - Anatomy, the Pubic Symphysis plays a vital role in anchoring the anterior abdominal wall, the inguinal region and the adductor group. The pelvic region thus functions as a transition zone between the upper extremities and the lower extremities. High risk activities such as soccer, ice-hockey and hockey require appropriate biomechanical functioning of all these areas. Musculoskeletal ultrasound and MRI evaluation of groin and anterior pelvis may illustrate shared structural ties and potential patterns of injury and groin pain (Table 9). Cognisance of the fact that associated pathology can occur due to abnormal stresses across the pelvic ring which may can lead to a secondary abnormality in the pelvic ring is required. However, associated abnormalities in the sacroiliac or sacrum are not always seen on conventional radiography. Recognition of the association of stress injury of the symphysis with back pain is most important so that inappropriate studies and diagnostic confusion can be avoided (Major, 2000). This factor is often not taken into account and recently at a Premier League football club, a player with ongoing groin pain had this issue resolved with radiological intervention and consequential specific injections into his sacro-iliac joint. Thus the radiological imaging should include adjacent structures where appropriate.

Slide 160



Cunningham et al. (2007) observed that in soccer players with "pubalgia," adductor dysfunction (adductor microtear) is a more frequent MRI finding than Osteitis Pubis as shown on Slide 160. This important finding may suggest that both entities are mechanically related and that Osteitis Pubis and adductor dysfunction frequently coexist and thus adductor dysfunction most likely precedes the development of Osteitis Pubis in soccer players. They surmised that the presence of oedema on fat-suppressed images of the symphysis may be a strong predictor of abnormality at this site in soccer players when compared with age- and sex-matched control subjects.

Up until 2015 there were no standardised MRI evaluation protocol for athletes who presented with symptoms that may relate to the pubic symphysis, the pubic bones, and the adductor muscle insertions. Branci et al. (2015) presented the Copenhagen Standardized MRI protocol which demonstrated moderate-to-substantial reliability in rating bone marrow oedema and varied from fair-to-substantial agreement for the majority of MRI features, but showed only slight agreement in rating adductor longus tendinopathy. This rigorous investigation also confirmed that while MRI evaluation seems to provide reasonable reliability in rating pubic bone marrow oedema, the evaluation of adductor tendinopathy in a clinical and research setting needs further resolution by continued development and testing of MRI acquisition protocols.

Within my professional career, I always take note of excessive pubic bone overload (and interact with the Radiologist, Specialist and te Coach) and then make a decision regarding off-loading the joint related to an individual's sport and training.

Summary - Pubis Bone Stress

Thus pubic bone stress is a natural phenomenon related to overload in sports and the complexity is relating it to the pathological consequence. Currently (2019), there is still no conclusion as to some form of "time line" of the radiological imaging that demonstrates when an asymptomatic pathology shown on imaging becomes symptomatic. Thus, as has been stated, in consultation with a radiologist, the specialist and where possible, the coach, I would off-load the joint, particularly with young children. This is not an easy decision, as one does not know how much pubic bone oedema is too much, particularly if it is asymptomatic. Further, the coach will not be compliant at all times with this decision making. I continue to relate to the specialists and radiologists to keep up to date with any possible time line of asymptomatic bone marrow oedema becoming symptomatic that may be developed.

6c. ii. Femoro-Acetabular Impingement – FAI /FAIS

Regarding Femoro-Acetabular Impingement (FAI), it should be noted that all studies show the original wording of FAI up until the Warwick Agreement (2016), whether the hip changes were symptomatic or asymptomatic. In this thesis I have thus utilised this nomenclature – FAI, as shown in the actual study, until the Warwick Agreement (2016) which clarified FAI as a morphological change, as opposed to Femoro-Acetabular Impingement Syndrome (FAIS), which is when the hip morphological changes become symptomatic due to the impingement. Thus, going forward, the term FAIS should be used only when there is an association with symptoms and this definitely gives more clarity to the diagnosis. As so many athletes have Cam and Pincer morphology depicted on radiological imaging, this observation should be combined with clinical tests to depict any symptoms and reach a valid diagnosis.

Recently, Zhou et al. (2020) showed the overall prevalence of radiographic findings consistent with FAI in young patients presenting with hip pain was 60.5% and findings for mixed-type FAI were the most prevalent. The connection between FAI and Long Standing Adductor-Related Groin Pain was discussed by Weir et al. (2011). They showed that radiological signs of FAI were frequently observed in patients presenting with Long Standing Adductor-Related Groin Pain.

However, they stress the fact that clinicians should be aware of the possible lack of correlation when assessing athletes with groin pain. Economopoulos et al. (2014) hypothesised that athletes with underlying FAI may be more prone to develop chronic groin pain and athletic pubalgia. They predicted that preoperative signs of impingement were a predictor for poor outcome after surgical repair of athletic pubalgia and that FAI may be a cause of continued groin pain after surgery for athletic pubalgia. Thus they stated patients with athletic pubalgia should be evaluated closely for the presence of FAI as this may be a factor to take into consideration when managing FAI and possible surgery. However, there is no clear definition as to what “athletic pubalgia” entails.

In their systematic review, Wright et al. (2015) discussed the radiological variables associated with progression of FAI of the hip. Of great concern is its potential association with labral tears and OA. Their outcome showed that there is moderate evidence that increased alpha angle at baseline is associated with progression of FAI to labral tear. Moderate evidence suggested a lack of association between other radiographic variables and progression of FAI. Thus once again, there appears to be no definitive outcome for the practical application of imaging and FAI.

A few studies showed the correlation between hip morphological changes and hip variations e.g. hip internal rotation (Kapron et al., 2012) and “Hip Vacuum Sign” (subluxation of the femoral head due to a lever mechanism between the femoral neck and the acetabular rim) (Schroder et al., 2016). The possibility of the hip morphology and these findings being linked could be misinterpreted, as these two factors do not have a direct cause and effect. Thus the implications of these finding are at this stage unclear.

6d. Further Radiological Studies and Implications

Table 10 - Further Studies and Implications

Author	Outcome
Davies et al. (2010).	Knowledge of the pertinent anatomy is required for the interpretation of groin pain. Careful MRI is recommended as this would improve diagnostic capabilities and **MRI is favoured over US as the initial imaging modality**, as it more readily allows symphyseal abnormalities to be identified. They developed a summary algorithm for the investigation and treatment of groin pain.
Godinho, (2012)	Labral tissue cannot be seen on conventional radiographs yet this remains the basis of all hip imaging, usually comprising AP pelvis and cross-table lateral projections. Lumbosacral, SIJ and trochanteric regions should be evaluated to exclude spondylotic changes, sacro-iliitis, trochanteric bursitis, ischio-femoral impingement and gluteal enthesopathy, all of which may mimic or refer hip symptoms. **Conventional MRI is best**

	avoided where labral abnormality is considered, due to poor sensitivity and unnecessary cost as a repeat arthrographic MR study will likely be required.
Branci et al. (2013).	Four main radiological findings seem to consistently appear: **degenerative changes at the pubic symphyseal joint, pathology at the adductor muscle insertions, pubic bone marrow oedema and the secondary cleft sign.** However, **the existing diagnostic terminology is confusing**, and the interpretation of radiological findings would benefit from imaging studies using a more systematic approach
Holmich, (2013)	Adductor injuries account for the majority of acute groin injuries. **Clinically diagnosed adductor injuries were often confirmed on imaging, whereas IP and RF injuries showed a different radiological injury location in more than one third of the cases**
Genovese et al. (2013)	**a) The traditional Xray may be very useful to detect a groin pain originating from the bone.** **b) Compared to dynamic US, MRI even if reported to have good diagnostic potential, leads to a high rate of false-negative results** because the examination is carried out with the patient in the recumbent position. Thus, **dynamic US turns out to be a diagnostically conclusive option**, if an **experienced examiner** performs it. **c) MRI is the most effective method in the identification of stress fractures** and thus able to detect the presence of oedema or of interstitial haemorrhage of bone marrow. **d)** The best imaging study for **assessing abnormalities of the labrum is the MRA**. **e)** Any radiographic abnormality may be imaged with CT. Investigation of **CT should be reserved for selected cases where it is essential in the differential diagnosis between stress response and a stress fracture.**
Almusa and Forster, (2014).	Although modern imaging does play a role in confirming a clinically suspected diagnosis, in order to determine the extent of injury and excluding other potential causes for the patient's pain, it is critical that the **appropriate diagnostic imaging is combined with a thorough history and physical examination.**
Chen et al. (2014).	Able to diagnose **adductor muscle avulsion at the symphysis pubis** with **ultrasound** for the symptoms of groin pain
Devitt et al. (2014).	In their patient population, **MRI demonstrated sensitivity and specificity** of 34% and 50%, respectively, in identifying any pathologic process of the LT. They concluded that MRI is capable of ruling out partial tears of the LT with high sensitivity (91%) and negative predictive value (67%).
Chang et al. (2015).	**Evaluated the accuracy of MRA in detecting LT tears with arthroscopic correlation and affirmed this accuracy**. They hypothesised that this intervention, with a valid classification system could help with management of these tears and prevent unnecessary surgery.
Holmich, 2016.	The value of **MRI in diagnosing LSGP is debatable** and needs further development. One should be careful of over-interpreting and this was frequently "more art than science".
Lee et al. (2016).	Showed radiographic identification of arthroscopically relevant acetabular structures and arthroscopically relevant proximal femoral structures. This study highlighted that **radiology, in addition to diagnostic values, is relevant to preoperative planning, intraoperative evaluations, and postoperative assessments.**

Serner et al. (2016).	**A multidimensional MRI assessment approach of acute MT groin injuries was described and found to be highly reproducible.** Injury location and injury extent can be scored reliably using 1.5 T MRI.
Heerey et al. (2018).	Seven electronic databases were searched for studies investigating the prevalence of hip intra-articular pathologies and hip OA using **X-ray, MRI, MRA or CT**. **The prevalence of hip intra-articular pathologies and hip OA in symptomatic and asymptomatic athletes is variable**. **Labral tears and cartilage defects appear to be seen often in athletes with and without pain.** Hip OA is rarely seen in athletes either with or without hip and groin pain.

SIJ: Sacro- Iliac Joint; MR: Magnetic Resonance; SRGP: Sports Related Groin Pain;

LT: Ligamentum Teres; MRA: Magnetic Resonance Arthrography; MT: Musculo-Tendinous;

US: Ultra Sound; MRI: Magnetic Resonance Imaging; CT: Computed Tomography;

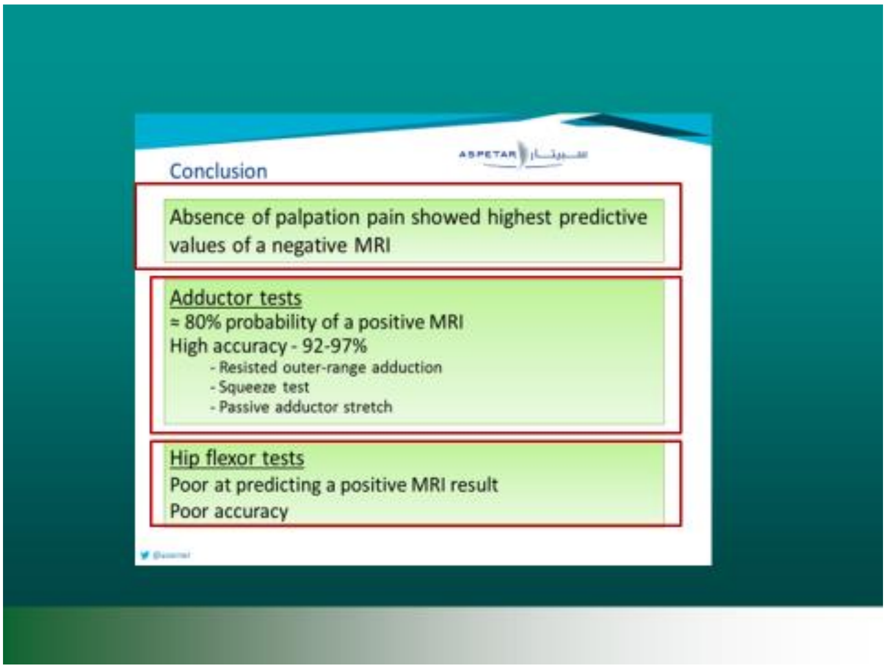
FMA: Football Medical Association.

As demonstrated in Table 10, this discrepancy between different radiological procedures and the lack of defined imaging protocols to highlight specific pathologies, remains complex in the management of groin pain in athletes and yet Pezzotta et al. (2018) were certain that MRI represented the gold standard imaging technique for the evaluation of Adductor Longus due to its ability not only to recognize, but also to classify acute lesions and define patient's prognosis. Further they stated that MRI was also useful to detect potential predisposing conditions and complications, which may correlate with return to play.

Serner et al. (2016) evaluated the ability of a standardised clinical examination of athletes with acute groin injuries to predict the presence and location of MRI findings. The study demonstrated that 21% of athletes had negative imaging and the absence of pain on palpation was best at predicting an MRI result. Specific adductor examination tests accurately predicted MRI adductor injuries. Hip flexor clinical tests were poor at predicating and localising MRI injuries in the hip flexors. Clinical examination appears sufficient to diagnose acute adductor injuries, whereas MRI could assist in accurately locating acute hip flexor injuries. Thus, again, the importance of clinical tests, as well as radiological imaging in the management of groin and hip pain cannot be underestimated.

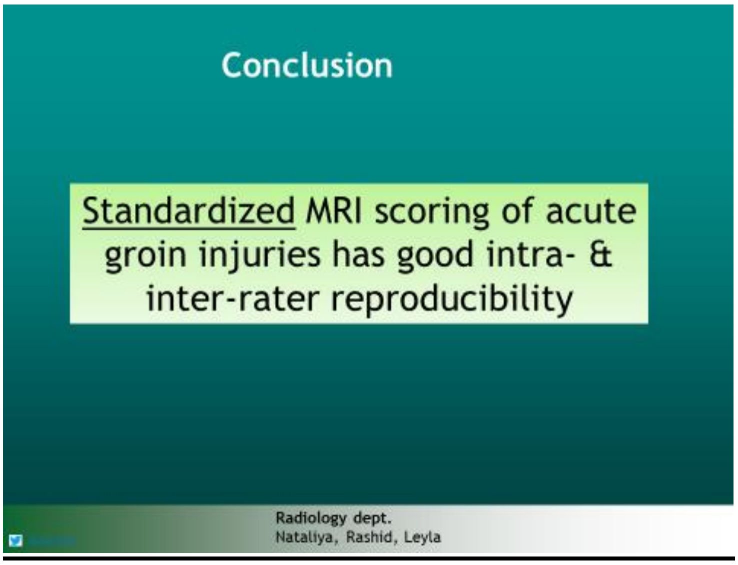
Slide 161

Slide 162



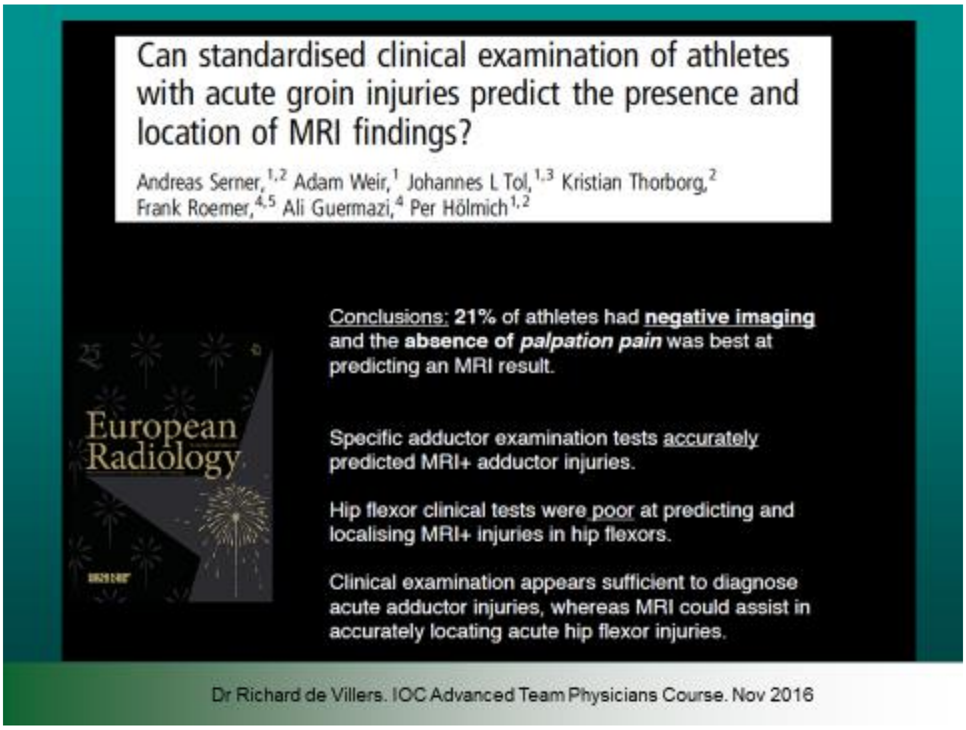
At the Hip Conference (St George's Park, Burton-on-Trent, Staffordshire, UK, 2016), Serner discussed his studies regarding acute groin injuries in athletes and the reliability of MRI assessment and the validity of radiological imaging. This was clearly demonstrated on Slide 161 and 162 and is useful for clinicians to evaluate the importance of certain radiological imaging for specific pathologies.

Slide 163



Their conclusion was that there was good intra- and inter-rate reproducibility with standardized MRI for acute groin injuries (Slide 163).

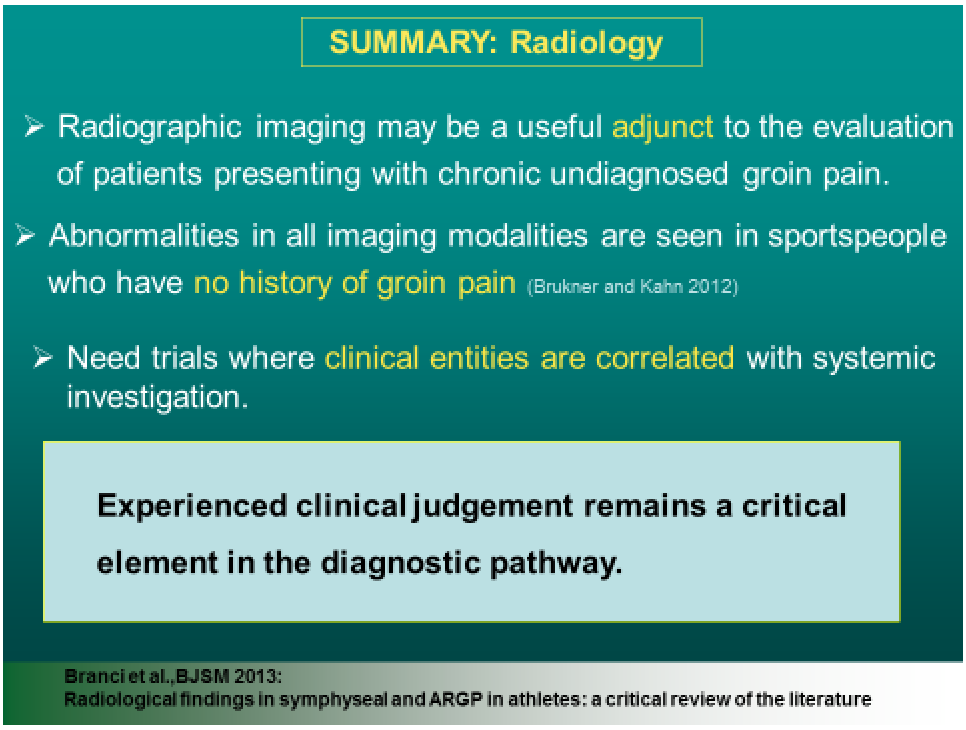
Slide 164



At the IOC Advanced Team Physician Course (Cape Town, South Africa, 2016), De Villiers re-affirmed the study by Serner et al. (2016) regarding radiological imaging, based on his professional experience in musculo-skeletal imaging (Slide 164). However, there have been many conflicting studies and presentations over the years as to the distinct validity of radiological imaging and its relevance in diagnosis. Dahlberg and Englund re-iterated that radiological findings need to be interpreted with caution and in combination with a complete clinical history and examination (2016). This has been verified in a number of studies (Almusa and Forster, 2014 and Ansede et al., 2011).

Thus in spite of ongoing studies and improved radiological imaging, the problem still remains as to the correlation of this imaging and the clinical findings. Most importantly, what all the studies reveal, is that existing diagnostic terminology is confusing and characterised by a general lack of consensus regarding radiological definitions and diagnostic criteria used by different authors. The Doha agreement (2015) has been a positive step in the right direction and may help future radiological interventions to become more precise and meaningful by zoning in to the structured clinical based taxonomy. A consensus statement on groin pain with regard to terminology, clinical evaluation and imaging assessment was compiled by a group of specialists (Bisciotti et al., 2016). They declared that the ideal situation was the development of a standard protocol that creates the greatest intra-observer and inter-observer agreement, which are crucial factors in determining the reliability of radiological results. They recommended a well-defined imaging protocol for all patients with groin pain and further proposed basic guidelines for evaluating clinical and imaging procedures which need to be analysed by clinicians dealing with groin pain. However, the efficacy of these guidelines still needs to be evaluated.

Slide 165



There is a plethora of studies on radiological imaging for groin and hips. However, as shown in Slide 165, there remains basic factors which need to be considered by all clinicians, particularly which form of imaging is most effective for groin and hip pain.

Table 11 – Specific Radiological Functionality

Author	Modality	Outcome
Chopra and Robinson, (2016).	MRI Plain Radiographs and Ultrasound	Principal imaging modality used to investigate groin pain, Plain radiographs and US can be very useful adjuncts in specific circumstances, especially if an alternative pathology needs to be excluded.
Vasileff et al. (2017).	Dynamic ultrasound	Inguinal hernia diagnosed.
Lee et al. (2017).	MRI and Ultrasound	These are valuable tools in diagnosing pathology in athletes with groin pain, with the added utility of treatment using US-guided intervention.
Bou Antoun et al. (2018).	Ultrasound MRI	Shows preperitoneal fat and to exclude true inguinal hernias, fascia transversalis bulging and inguinal ring dilatation. To assess injuries of RA, AL enthesis and OS. Its **accuracy** for the diagnosis of inguinal-related groin pain **remains debated**

Ducouret et al. (2018)	MRI	**77.78% accuracy** for chronic groin pain
HerniaSurge Group (2018).	All Radiography	**Inguinal Hernia diagnosis can be confirmed by physical examination alone** in the vast majority of patients with appropriate signs and symptoms. Rarely, US is necessary. MRI or CT scan or herniography may be needed.
Todeschini et al. (2019).	US and MRI US	The evaluation of AP should be performed with radiography, US, and MRI. High BMI, muscle injuries, geodes, and osteophytes are findings associated with pubalgia. US has low sensitivity to detect injuries of the common aponeurosis of the rectus abdominis/adductor longus muscles.
Lee et al. (2019).	MRI CTA	The accuracy of **MRI** to detect an **acetabular labral tear and a chondral lesion** of the hip joint **was not sufficient**. **CTA** was **reliable** in the diagnosis of **acetabular labral tears.** However, both **CTA and MRI** were also of **limited value to detect chondral lesions.**

US: Ultrasound; CTA: Computed Tomography Arthrography; RA: Rectus Abdominis; AL: Adductor Longus enthesis; OS: Osteitis Symphysis; AP: Athletic Pubalgia

A few examples of the effects of different radiological procedures are shown in Table 11. However, there is still much debate as to the most productive intervention. Due to the overlap of many pathologies, as well as the plethora of asymptomatic findings, the radiological imaging should be viewed with caution.

Conclusion - Radiology

The key message regarding radiological imaging is that it may be useful in certain circumstances when trying to identify any abnormalities which have been noted during clinical examination such as adductor tendinopathy or avulsion, which may be the cause of the athlete's groin pain. However, one should understand the limitations and be cautious when making a diagnosis based on radiological signs only, as we have clearly observed from all the studies that there is a high number of abnormal radiological findings in asymptomatic hips and groins of sportsmen and women. To date (2020) imaging is not able to differentiate between asymptomatic and symptomatic athletes. Therefore, it is important that the radiological findings for groin and hips are always seen in context of the clinical history and assessment.

In Premier League (and in other elite sports) radiological imaging is often a prerequisite tool for pre-screening / pre-signing and may be erroneously used as a major factor in diagnosis and possibly relied on too heavily. In the past 13 years of dealing with elite sport and observing pre-screening outcomes, I have noted the high percentage of radiological changes on the imaging which are not related to the groin pain i.e. are asymptomatic. The concern is that it would be useful to know when the radiological changes may lead to a symptomatic pathology and thus devise a prevention strategy. Further it would be useful if future investigations could determine whether these asymptomatic findings predict future disabilities such as OA.

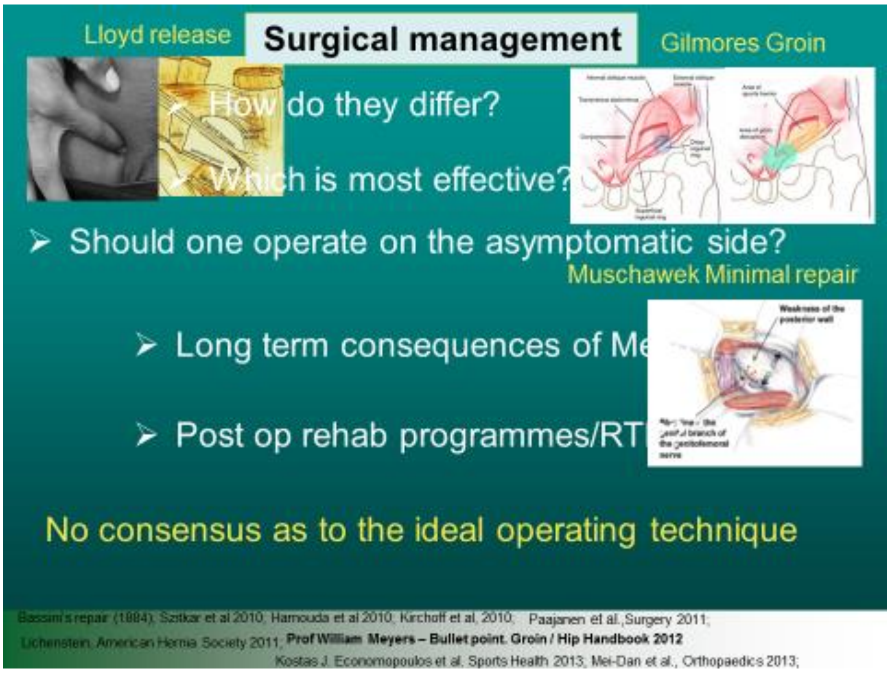
The basis of this thesis is to highlight the importance of a prevention strategy for any groin or hip pathology from developing, regardless of the specific diagnosis or whether the morphological changes are asymptomatic or symptomatic on radiological imaging.

Chapter 7: Surgery

7a. Background

There are many different surgical procedures for the groin and hip regions. To date (2020), there is no gold standard surgical procedure largely due to the multifaceted aetiology and overlapping pathologies which make diagnosis difficult. Surgery has been the most contentious issue in the management of groin and hip pain. Not only the dilemma of whether one should operate at all, but also the timing of the surgery. Further, each surgeon has his / her specific surgical procedure which requires a definitive diagnosis in order to send the patient to the specific specialist for the operation. This has resulted in no clear standardized surgical procedure and there continues to be much debate as to why, when and how one should operate. In spite of the Manchester Agreement (2012) and the Doha Agreement (2014), there was no clear favoured surgical method as an outcome. Although these meetings were positive in terms of collaboration and an attempt to get some consensus from all specialists around the world, it was disappointing in that the majority of the participants were surgeons (at the Manchester Agreement). Thus the slant would be towards surgical intervention. My belief is that one should not blindly follow outcomes such as this and clinicians need to continue analysing all research and above all, observe one's own's practice with ongoing changes according to positive outcomes. This is the problem in elite sports such a Premier League where the importance of a "quick fix" is paramount. From my observation and analytical assessment of all groin and hip pathologies over the years, in many instances the intervention does not work as the original diagnosis was incorrect due to the complexity and the often overlapping entities. Thus the surgeon to whom the athlete was referred with his/her specific procedure was incorrect for the particular pathology. I thus find it important to present to surgeons and respective clinicians regarding surgery (including Mr Gilmores' colleagues in London, 2013, Arsenal and Blackburn Rovers medical colleagues, 2015, 2016, 2017, Hip Conference in South Africa to Hip surgeons, 2017, Bournemouth and Crystal Palace Football Clubs, 2019) and explaining how many surgical procedures may be prevented with a preventative programme being implemented, either in the first place as a specific musculo-skeletal strengthening protocol, or when an athelete has any groin or hip pain.

Slide 166



Many questions arise when considering the complexity of surgical procedures (Slide 166). What exactly is the difference between these operations? What is the best outcome? Should one operate on the asymptomatic side? What is the long term consequences of mesh? What is the ideal post-operative rehabilitation protocol? There are many studies which are published with these questions in mind. However, from attending groin and hip conferences, such as the Football Association Meeting (London, United Kingdom, 2012), where there was strong disagreement between two specialists, it appears that each surgeon tends to be biased towards his/her preferred surgical procedure and this in reflected in the research studies looking at their surgical technique.

Historically, Dr Gilmore was one of the first specialists to analyse and undertake surgery for groin problems. In 1998 his study demonstrated the fact that between 1980 and 1998, of 4,500 patients referred to his clinic in London, 2,700 were treated surgically and he reported a success rate of 97%.

Slide 167

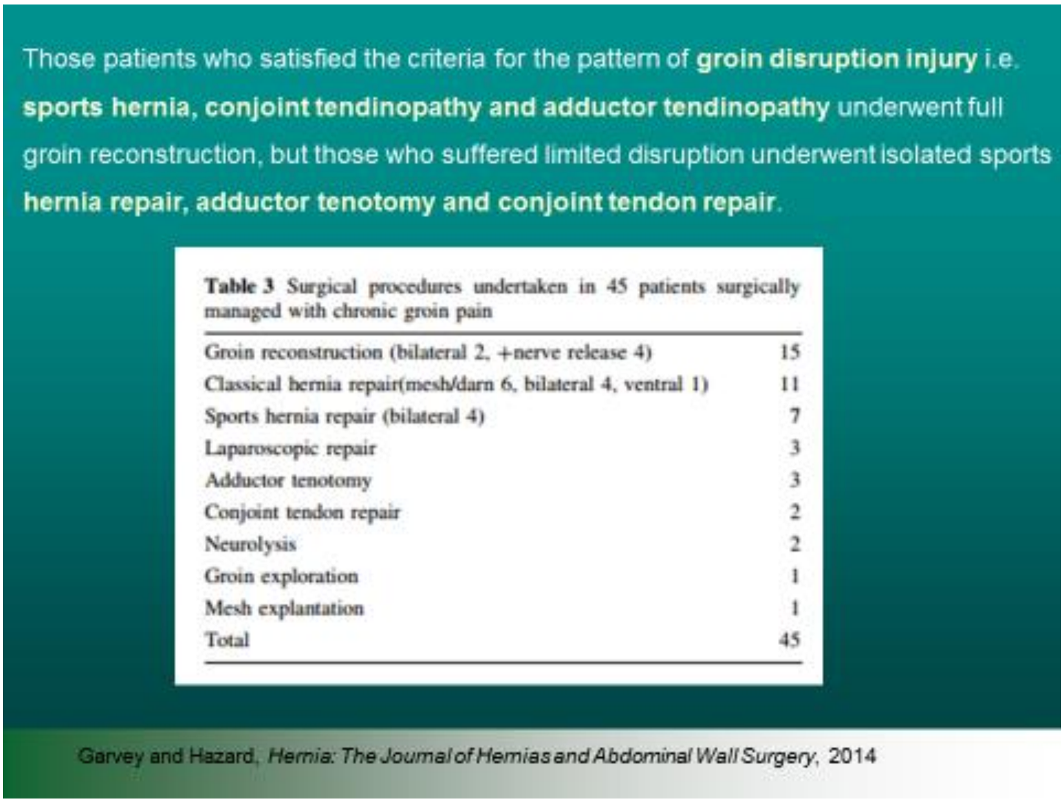


Table 3 Surgical procedures undertaken in 45 patients surgically managed with chronic groin pain

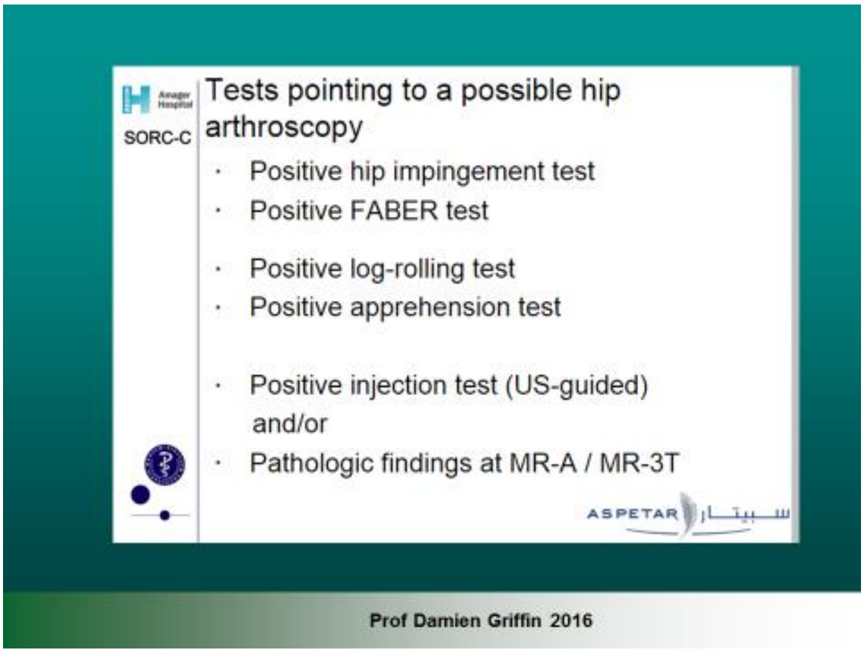
Groin reconstruction (bilateral 2, +nerve release 4)	15
Classical hernia repair(mesh/darn 6, bilateral 4, ventral 1)	11
Sports hernia repair (bilateral 4)	7
Laparoscopic repair	3
Adductor tenotomy	3
Conjoint tendon repair	2
Neurolysis	2
Groin exploration	1
Mesh explantation	1
Total	45

Examples of the multiple pathologies and different procedures is shown in the slide above (Garvey and Hazard, 2014). (Slide 167). A cause for concern is that it shows that surgery was a given for all those "possible" pathologies. Surgery is frequently proposed for numerous pathologies while the efficacy of these approaches are not clear although surgeons have attempted to have a structure for surgical procedures (Garvey, 2012; Morales-Conde, 2010)

According to Orchard et al. (2000) and Garvey (2012), reconstruction surgery achieved results by correcting imbalance across the pubic symphysis created by abnormal adductor and abdominal muscles and reducing compartment pressures. My impression is that many of the surgical procedures have nothing to do with correcting imbalances e.g. Muschaweck's minimal repair. Further, this is an interesting observation when one considers that perhaps these imbalances and the resultant pathologies (and consequential surgical procedures) may be prevented with the correct pre-habilitation / prevention strategies to correct and strengthen these muscle imbalances around the pubic area in the first place. This is in part the motivation behind much of this thesis. Thus it would be most beneficial if studies could be undertaken to examine if surgery may be prevented by an in-depth, specific, individualised rehabilitation programme for an injured player to restore muscle balance and compare this to current surgical procedures. Similarly, a specific individualised preventative programme to prevent the muscle imbalance from developing.

Southampton Football Club have initiated a preventative protocol and are currently experiencing very few groin/hip problems. Their programme was described at the Warwick Sports Hip Meeting (2016) and research as to the programme's effectiveness is currently being undertaken. This anecdotal evidence needs to be confirmed scientifically but provides a starting point for preventative rehabilitation.

Slide 168



At the Aspetar Conference (Doha, Qatar, 2014) and discussed again at the Warwick Conference (London, United Kingdom, 2016), Griffin showed the pertinent clinical tests including FABER test, log- rolling test and apprehensions test which may point towards possible hip arthroscopy (Slide 168). As there is still much debate around the validity of many of these tests, this should be seen as a guide and not a given protocol.

Although general hip arthroscopy has increased in popularity in the past years (Marin-Pena et al., 2017 and Palmer et al., 2016), it would be useful to have statistics regarding the increase rate of hip surgery in the sports domain.

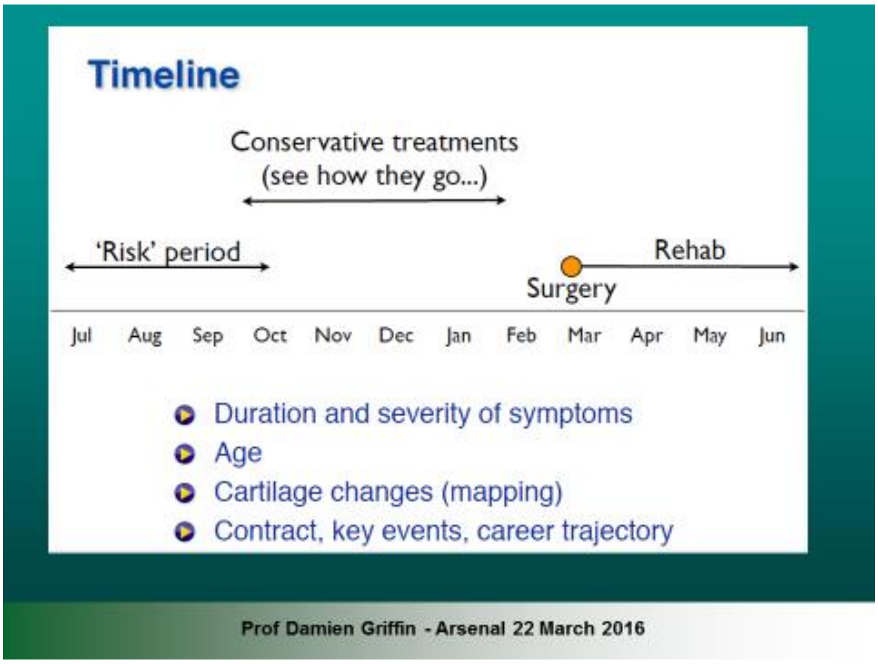
7b. Different Surgical procedures.

A number of different surgical procedures have been described, which include open versus laproscopic, mesh versus no mesh, minimal or broad pelvic floor repair (Amato et al., 2012; Campanelli et al., 2017; Hemingway et al., 2003; Muschaweck and Berger, 2010; Patil et al., 2016; Samaali et al., 2016; Zuvela, 2011) and for the most part, studies have found a return to sport outcome of between 64-100% for all procedures.

Slide 169

Griffin (2016) proposed that the arthroscopic management for pincer or cam morphology and concomitant debridement or repair of co-existing labral tears and cartilage injuries was the best procedure and only smaller and less significant lesions could probably be treated non-surgically (Slide 169). Currently, there is much discussion amongst all the specialists and clinicians around this debatable protocol and the necessity for surgery as opposed to conservative rehabilitation. Further, his recommendation of three to six months of lay-off post-surgery is not an acceptable solution by many elite sports groups who demand a "quick fix" procedure.

Slide 170



Slide 170 highlights an important time line for conservative treatment and the variables such as specific player's contracts, duration and severity of the symptoms, age and cartilage changes which might lead to surgical procedures. This observation, proposed by leading hip Specialist in Great Britain, Damien Griffin is to be considered by medical personnel dealing with elite athletes. Thus I believe that individualising every athlete and their varied circumstances and demands is imperative.

Many studies discuss chronic athletic groin pain and classify these into open and laparoscopic techniques. What is important to bear in mind is that many of these nomenclatures regarding diagnosis and surgical procedures are not in use currently (2019) e.g. Athletic Pubalgia, Gilmores Groin and Groin Disruption injury.

Current evidence to support both surgical and conservative interventions for FAI: is based on low-level research (Mansell et al., 2016). In their study of 222 participants aged 18 to 60 years with symptomatic FAI, Palmer et al. (2019) concluded that these patients referred to secondary or tertiary care, achieve superior outcomes with arthroscopic hip surgery than with physiotherapy and activity modification. It would be most useful to have these statistics performed on athletes and see if the outcome was similar. Although there are studies regarding physical therapy versus surgical intervention (King et al., 2015; Palmer et al., 2019; Pennock et al., 2018; Thorborg, 2014), there is no research to prove that the time off was more relevant than the surgical intervention. The contribution of time away from sport and the rehabilitation programme assigned after surgery to the return to play outcome is not known and the potential importance of these variables to the ultimate outcome of surgery should not be overlooked. One speculates as to whether these positive return to sport after surgery statistics may be related to time off sport and rehabilitation and thus not necessarily related to the surgery.

Table 11 discusses a few of the many studies explaining outcomes of different surgical procedures.

Table 12: Different Surgical Procedures

Author	Surgery	Outcome
Ganz et al. (2001).	Anterior dislocation through a **posterior approach with a 'trochanteric flip' osteotomy.** External rotator muscles are not divided and the medial femoral circumflex artery is protected by the intact obturator externus.	Surgical dislocation of the hip is rarely undertaken due to the potential danger to the vascularity of the femoral head. **It is proposed that recognition of this entity and early intervention before the degenerative process is advanced**, is likely to have a considerable impact on the natural history of the disease, delaying the onset of end-stage arthritis in this young group of patients.
Muschaweck and Berger, (2010); Minnich et al. (2011); Muschaweck et al. (2015).	**Minimal repair technique**	Recommended only **4 to 6 weeks of conservative treatment pre-operatively** to avoid chronic regional pain syndrome developing. The **defect of the posterior wall of the inguinal canal is not enlarged**, the **suture is nearly tension-free** and the **slide-bearing movement of the abdominal wall is preserved.** This technique **does not expose the patient to possible risks related to mesh insertion or laparoscopic procedures**. Return to training = 10 days
Garvey (2012).	Favours the term "groin disruption injury" Performs a 'groin reconstruction' operation after a period of three to six months of failed conservative treatment.	Groin reconstruction surgery achieves results by **correcting imbalance across the PS** created by abnormal Add and Abd muscles and reducing compartment pressures. A randomised controlled clinical trial is required to determine whether **this injury responds better to active physiotherapy or to surgery** and **which type of surgery is more successful**: open (tension free tissue repair, Shouldice, Lichtenstein, or minimal) or TEP.

Economopoulos et al. (2013)	**Minimal repair technique**	The minimal repair technique allowed athletes with sports hernias to **return to play faster than patients treated with the modified Bassini**.
Garvey and Hazard, (2014).	**Repair of the posterior inguinal canal wall** (herniorrhaphy), repair of the conjoint tendon and AL tenotomy.	**Groin disruption due to functional instability of the pelvis**. Surgical management has a role in cases of failed conservative treatment, and a groin reconstruction is the preferred procedure.
Tansey et al. (2015).	**Rectus Abdominus and Adductor Longus Repair**.	**Complete avulsion of the adductor sleeve complex** i.e. AL, Pectineus and RA required **anatomical re-attachment of the avulsed tissues and mesh reinforcement of the posterior inguinal wall.**
McDonald et al. (2014).	**Microfracture repair**	Microfracture repair is a marrow-stimulating technique used to **treat cartilage defects associated with FAI, instability, or traumatic hip injury**. These defects have a low probability of healing spontaneously and therefore often require surgical intervention. **There is positive outcome for microfracture repair and return to elite performance level is possible**
Chalmers et al. (2017).	**Total hip arthroplasty** for impingement of the IP tendon.	**Non-operative management** of IP impingement led to **groin pain resolution in 50% of patients**. In patients with minimal acetabular component prominence, **IP release provided a high rate of success.**
Bokkerink et al. (2017).	**TREPP**.	**TREPP seems to be a feasible alternative for recurrent inguinal hernia repair** after an initial operation according to Lichtenstein**.**
Emblom et al. (2018)	**RA-AL aponeurotic plate repair** by the method of an ADD-to–RA turn-up flap.	This is a **safe procedure with high RTP success.** Patients who had previously undergone inguinal hernia repair or other hip/pelvic-related surgery and female patients had worse outcomes.
Kockerling et al. (2018).	Comparison groups for **Shouldice versus Lichtenstein repair**	For a selected group of patients, the Shouldice technique can be used for primary unilateral inguinal hernia repair **while achieving an outcome comparable to that of Lichtenstein, TEP and TAPP operations**.

PS: Pubic Symphysis; ADD: Adductor; Abd: Abductor; AL: Adductor Longus;

TEP: Totally extra-peritoneal repair; OA: Osteoarthritis; AP: Athletic Pubalgia;

RA: Rectus Abdominus; RTP: Return to Play; TAPP: transabdominal preperitoneal repair; TEP: totally extraperitoneal repair; IP: Iliopsoas; TREPP: The TransREctus sheath PrePeritoneal; AL: Adductor Longus; J: Journal; LMR: Lichtenstein Mesh Repair;

MBR: Modified Bassini's Repair

Table 12 shows the variable surgical procedures which to this day is a point of discussion amongst clinicians.

Arthroscopic repair has been extensively researched and is constantly evolving. The general outcome is that hip arthroscopy is a safe procedure with stable improvement in patient-reported outcome measures from 2 to 5 years follow up (Bayley et al., 2017; Chandrasekaran et al., 2017; Chen et al., 2019; Domb et al., 2017; Litrenta et al., 2019; May, 2019; Mohan et al., 2017; Nwachukwu et al., 2018; Rego et al., 2018; Sariali and Vandenbulcke, 2018; Shibata et al., 2017). The need for guidelines for management of inguinal hernia pathologies, was acknowledged by Bittner et al. (2011), with a focus on technique and special problems in transabdominal preperitoneal patch plasty (TAPP) and total extraperitoneal patch plasty (TEP). The laparoscopic and endoscopic repair has evolved over the years (Antoniou et al., 2014; Byrd et al., 2017; Grammatopolous et al., 2017; Kockerling, 2019; Lerebours et al., 2016; Mosier et al., 2016; Varcus et al., 2016). Martin, (2015) summed up the complexity of surgical management by stating that an understanding of the anatomy, biomechanics, clinical examination and diagnostic strategies and treatment of each structure around the hip is the foundation leading to positive outcomes. This was concurred by Konschake et al. (2019).

On the 2nd of August, 2017, I received an e mail from Dr Muschaweck explaining her most recent thoughts on her minimal repair technique. Her response was that her surgical technique had not changed and was "more successful than ever". She ascertained that the recovery was fast (within 2 weeks) and the postoperative pain level was very low. Having observed this excellent surgical procedure performed by Dr Muschaweck (Wellington Hospital, London 2016), I appreciate the early return to sport after this minimal technique undertaken for a deficient posterior wall of the inguinal canal. However, unfortunately, the athletes often have not got this specific diagnosis and have other pathologies, including conjoint and adductor tendinopathies and nerve entrapment and require further surgery.

The arthroscope was revolutionary in clarifying this clinical picture (Byrd et al., 2006). Prior to this, specific conditions were poorly diagnosed, generally leading to misdirected and unsuccessful treatment. Regarding hip arthroscopy, it is important to remember that around the hip, various intra- and extra articular conditions may coexist, further challenging the clinician (Benoy, 2018). Previously, de Sa et al. (2016) found that overall, pathological causes of groin pain requiring surgery was the same for intra-articular and extra-articular structures.
Thus groin hernia surgery remains an ongoing field of investigation. The problem, as has been mentioned previously, is that the initial pain suffered by the athlete may not have been from the

inguinal ligament. Further, by working in the Premier League and getting an overview of all surgical procedures and return to play, it is fairly common to observe players who move from one surgeon to the next for different procedures for the same injury. This raises the question of the effectiveness of surgery for non-specific or overlapping pathologies or the effectiveness of the return to play protocols followed by the players.

All these surgical procedures should be understood and analysed by the clinician (even observing the actual operation, where possible), as this communication with the surgeon and understanding will give the clinician an idea of possible difficulties post-operative rehabilitation and different time frames.

Slide 171

Table 1. Outcomes after surgical management of athletic publagia/sports hernia

Reference	Repair Type	Outcome
Brannigan et al (2000)[2] Gilmore (1991)[8]	Open/no mesh	95% return to sports
Hackney (1993)[9]	Open/no mesh	87% return to sports
Brown et al (2008)[3]	Open/mesh	99% return to sports
Kluin et al (2004)[15]	Laparoscopic/mesh	93% return to sports
Gentisaris et al (2004)[6]	Laparoscopic/mesh	100% return to sports
Muschaweck and Berger (2010)[22]	Open/minimal repair	84% return to sports
Meyers et al (2000)[19] Meyers et al (2008)[20]	Open/broad pelvic floor repair	95% return to sports
Jakoi et al (2013)[14]	Various types/hockey (National Hockey League)	80% return to hockey

As can be seen in Slide 171 (Larson 2014) there are many variable surgical procedures for inguinal repair. It is interesting to note that most of the surgical studies do show a very high percentage of return to sport. However, much discussion ensues at conferences by various sports specialists as to the exact percentages as claimed by these surgeons. This feedback is an important component of my analysis and approach to management of groin and hip problems or potential problems.

Many studies compare different procedures e.g. Campanelli et al. (2017) – open anterior repair versus endoscopic repair; Chandrasekaran et al. (2015) – open versus endoscopic gluteal repair; Economopoulos et al. (2013) - modified Bassini repair versus minimal repair; Muschaweck et al. (2002) – Shouldice repair versus Mesh; Romain et al. (2018) – patient's satisfaction:

Lichtenstein's technique, Trans-Inguinal Preperitoneal technique, Totally Extraperitoneal approach and Transabdominal Preperitoneal; Sharma et al. (2015) - open pre-peritoneal mesh repair versus Lichtenstein mesh repair; Scheuermann et al. (2017) – TAPP vs Lichenstein. Recently Aiolfi et al. (2019) suggested that Open, TAPP, TEP, and rTAPP (robotic TAPP) seem comparable in the short term. They summarised the complexity of surgical procedures by stating that this management of inguinal hernia is evolving and the effect of the adoption of innovative minimally invasive techniques requires further investigation in the long term. They concluded with the succinct point that ultimately, the choice of the most suitable treatment should be based on individual surgeon expertise and tailored to each patient.

Essentially, although each study verifies a particular outcome and highlights certain complications such as those linked to open surgery, there is no general consensus overall as to the best surgical procedure.

7b i. Adductor Tenotomy

Chronic adductor enthesopathy is a well-known cause of groin pain in athletes. Percutaneous nonselective adductor tenotomies give mixed results and not always predictable outcomes (Schilders et al., 2013). The table below demonstrates a few varied studies on adductor tendon surgical procedures.

Table 13: Adductor Tenotomy

Author	Title	Surgery/ Intervention	Outcome
Schilders et al. (2007; 2009)	ARGP in recreational and competitive athletes. Role of adductor enthesis, MRI and entheseal pubic cleft injections.	**Pubic cleft injections** for ARGP in athletes.	A single entheseal pubic cleft injection can be expected to **afford at least one year of relief** of ARGP in a recreational or competitive athlete with normal findings on a MRI scan. They advised that it should be employed only as a diagnostic test or **short-term treatment** for a competitive athlete. A **surgical procedure** (possibly a tenotomy) **would be the next** intervention.
Robertson et al. (2011).	Add tenotomy in the management of groin pain in athletes.	**Add Tenotomy.**	Add tenotomy in athletes with **severely incapacitating pain which fails to respond to Conservative Management** offers the best opportunity of returning

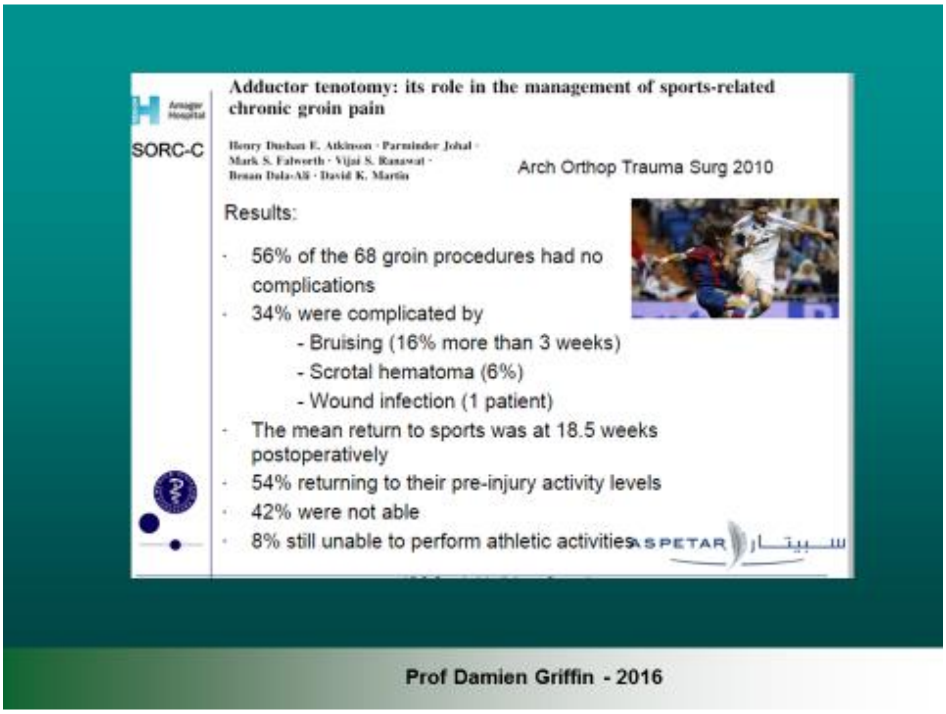
			to competitive sport. **84% patients returned to Level 1 performance** i.e. optimal performance with no pain.
Schilders et al. (2013)	Effectiveness of a selective partial adductor release for chronic ARGP in professional athletes.	**Partial adductor release** for chronic ARGP in professional athletes.	Effectiveness of a selective partial adductor release for ARGP in professional athletes with **excellent pain relief for chronic adductor enthesopathy**. There was a consistent **high rate of return to the preinjury level of sport.**
Hopp et al. (2013).	OP and Add tendinopathy in athletes: A novel arthroscopic PS curettage and Add reattachment.	**Arthroscopic PS curettage and adductor reattachment**.	They concluded that in select cases of patients with recurrent OP and concomitant Add tendinopathy, **their surgical procedure** with an arthroscopic curettage of the pubic bone in combination with restoration of the Add tendon origin, **addressed both coexisting causes.**
Sansone et al. (2014).	Can hip impingement be mistaken for tendon pain in the groin?	Evaluation of the long-term outcome in athletes who underwent **Add tenotomy, RA tenotomy or both,** due to long-standing groin pain.	**Tenotomy for pubalgia yielded a satisfactory long-term outcome**. It is recommended that the hip should be carefully evaluated for hip impingement before tenotomy is considered as treatment for athletes with pubalgia.
Gill et al. (2014).	Surgical technique for treatment of recalcitrant Add Longus tendinopathy.	**The tendon is fully released 2 cm distal to its origin using electrocautery**. **The freed tendon is then manually displaced approximately 5 cm distally into the thigh to prevent reattachment**.	**Non-operative** management **is not always successful.** **Return to full competition at 12 weeks postoperatively.**
Hopp et al. (2013). Hopp et al. (2014).	2013: OP and Add tendinopathy in athletes: a novel arthroscopic PB curettage and Add reattachment. 2014: Arthroscopic pubic symphysis debridement and Add enthesis repair in athletes with AP: technical note and video illustration.	**The PS is debrided arthroscopically and the degenerated origin of Add tendon (enthesis) is excised and reattached.**	Stability-preserving arthroscopic PS curettage with Add debridement and reattachment of the origin **addresses both coexisting causes** i.e. **recurrent OP and concomitant Add tendinopathy**

Sansone et al. (2014)	Can hip impingement be mistaken for tendon pain in the groin? A long-term follow-up of tenotomy for groin pain in athletes.	**Adductor tenotomy for Pubalgia**	Yielded a **satisfactory long-term outcome,** with 3 of 4 athletes being able to return to their pre-injury sport. The **athletes that did not return to their pre-injury sport had higher frequency of positive hip impingement test and inferior functional outcome** compared with the athletes that did return to their pre-injury sport.
Rossidis et al. (2015).	Laparoscopic hernia repair with Add tenotomy for AP: an established procedure for an obscure entity.	**Laparoscopic totally extra-peritoneal hernia repair with synthetic mesh accompanied with an ipsilateral Add Longus tenotomy**.	Allows patients to **return to sports-related activity early with minimal complications.**
Tansey et al. (2015).	Description of an uncommon variant of combined Add injury, namely complete avulsion of Add Long, Pectineus and RA .	**Anatomical re-attachment of the avulsed tissues and mesh reinforcement of the posterior inguinal** wall in seven patients.	**Successful return to high-level sports** following early surgical repair of combined Add complex and rectus abdominis avulsion.
Harr and Brody, (2017).	Sports hernia repair with Add tenotomy.	In athletes with MRI confirmation of RA and Add Longus injuries, **Add tenotomies along with a herniorraphy** may improve outcomes.	The procedure involves **fascial release of the RA and Add tenotomy** is performed to relieve the opposing vector forces on the pubic bone. This repair to reinforce the inguinal floor **prevents mesh-related complications, especially in young athletes.**
Bharam et al. (2018).	Endoscopic proximal Add lengthening for chronic ARGP.	**An endoscopic z-lengthening of the proximal Add tendon.**	**Various tenotomy techniques** have been described including open, partial, and percutaneous approaches. However, **many develop adductor weakness**. This **technique has the potential to minimize complications** associated with open procedures such as incisional pain and neurovascular injury.

RA: Rectus Abdominus; OP: Osteitis Pubis; Add: Adductor; PS: Pubic Symphysis; PB: Pubic Bone; AP: Athletic Pubalgia; ARGP: Adductor-related Groin Pain

As has been explained in Chapter 3 - Anatomy, adductor dysfunction is the most common cause of groin pain in athletes, with the Adductor Longus tendon being most commonly involved (Pezzotta et al., 2018). As shown in Table 13, adductor tenotomy has become more common and successful over the years. My point of view is that strengthening of these muscles in the first place may well prevent this high rate of adductor pathologies from developing.

Slide 172

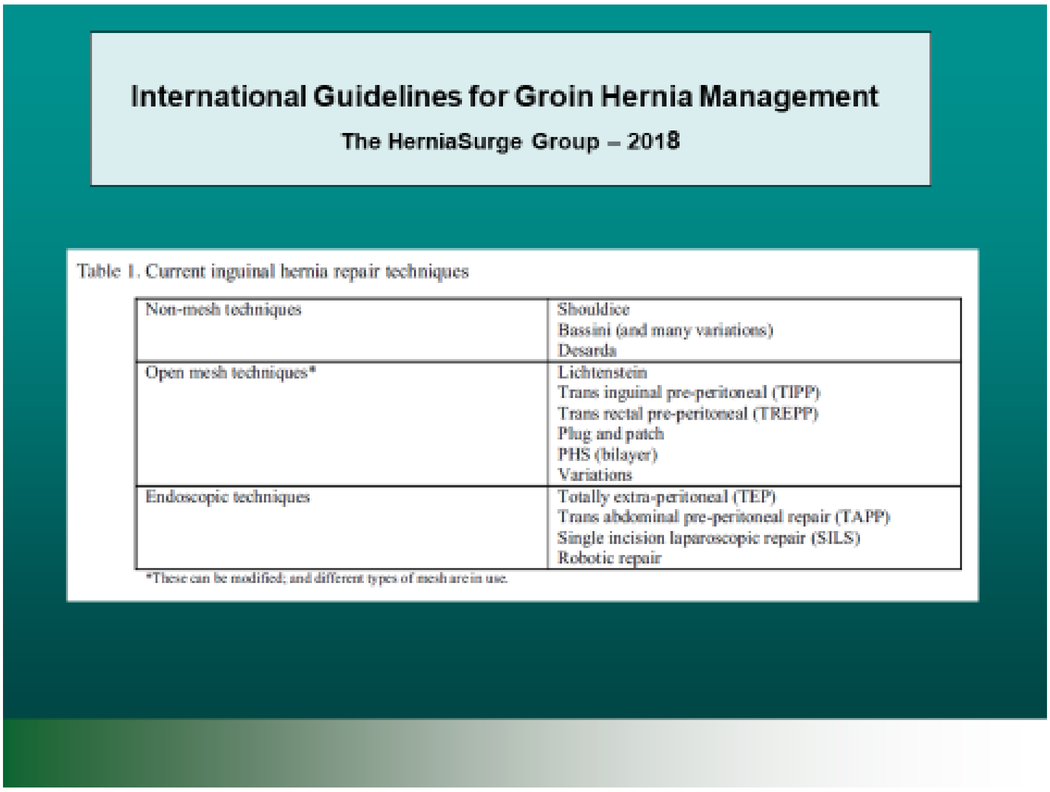


Slide 172 sums up the overall outcome of adductor tenotomy with minimal complications and an average return to sport being 18.5 weeks post operatively. From my 13 years working in Premier League, I have not seen any player having to give up his football after undergoing an adductor tenotomy.

There has been some discussion regarding the benefit of performing bilateral adductor longus release in patients who may only have unilateral symptoms (Maffulli et al., 2012). It has been suggested that this prophylactic release of the asymptomatic tendon at the time of release of the symptomatic tendon would prevent the need for future intervention. However, Gill et al. (2014) found that patients who presented with unilateral symptoms generally did not require a contralateral release later and, therefore, did not perform this.

7b ii. Controversies regarding Mesh.

Slide 173



For many years now, the gold standard for inguinal hernia surgical treatment has been mesh repair which can be performed open or laparoscopically. However, whether there is still an indication for non-mesh repair, or when a mesh repair needs to be done open or laparoscopically remains to be determined. There is no uniform technique applicable to all patients. Hernia surgeons individualize, based mostly on their own experience as scientific foundation is lacking (Slide 173).

Table 14: Mesh repair

Author	Title	Outcome
Woeste et al. (2014).	Use of biological meshes in abdominal wall reconstruction: Results of a survey in Germany.	The **advantage** of this choice is a **one stage repair despite the contamination**. As the results of this survey are not able to provide arguments for the use of different meshes this question should be further investigated with a randomized controlled trial.
Zwaans et al. (2017)	Mesh removal and selective neurectomy for persistent groin pain following lichtenstein repair.	Mesh removal either or not combined with tailored neurectomy is **beneficial in two of three patients with characteristics of mesh-related inguinodynia following Lichtenstein hernia repair** who are refractory to alternative pain treatments

Chihara et al. (2017).	TEP removal of an Infected Mesh by Laparoscopy after Open Preperitoneal Repair: Initial Case Report	Infected mesh **was removed successfully by laparoscopic surgery** via a totally extraperitoneal approach. The **laparoscopic approach provides several advantages**, including less postoperative pain, a shorter hospital stay, and earlier rehabilitation.
Slooter et al. (2018)	Laparoscopic mesh removal for otherwise intractable inguinal pain following endoscopic hernia repair is feasible, safe and may be effective in selected patients	Laparoscopic **mesh removal is a feasible, safe, and effective option** in selected patients with chronic groin pain after endoscopic hernia repair in the hands of an experienced surgeon.
Lockhart et al. (2018)	Mesh versus non-mesh for inguinal and femoral hernia repair.	Compared to non-mesh repairs, **mesh repairs probably reduce the rate of hernia recurrence, and reduce visceral or neurovascular injuries.** Mesh repairs may result in a reduced length of hospital stay and time to return to ADL. **Non-mesh repair is less likely to cause seroma formation** and has been favoured in low-income countries due to low cost and reduced availability of mesh materials.
HerniaSurge Group. (2018).	International guidelines for groin hernia management.	Synthetic mesh fixation in both open and laparo-endoscopic hernia repair **involves a consideration of the strength of fixation versus the risk of trauma to local tissues and nerve damage** through entrapment. **Mesh fixation complications** include: mesh migration, adhesions, erosion and hernia recurrence, ‘‘meshoma’’ formation, tack hernias, chronic pain and infection

TEP: Totally Extraperitoneal; ADL: Activities of daily Living

The use of mesh is currently an ongoing debate and as Table 14 demonstrates, the merits and disadvantages are constantly being researched. This has also been discussed in depth at various conferences and amongst specialists such as the Football Association (FA) Medical conference in London (2014), where the two speakers, Dr Muschaweck and Mr Lloyd, had conflicting opinions about the use of mesh and the possibility of infection. Dr Muschaweck uses mesh sparingly, whilst similar to a number of other surgeons, Mr Lloyd uses it regularly for his inguinal repair procedures, both surgical procedures mostly having successful outcomes. When I attended surgery in London performed by Dr Muschaweck (2016), it was interesting to note that during the procedure she removed mesh and showed me the resultant infection. She related a number of athletes who consulted with her post surgery by other specialists and the consequences of the mesh utilised. However, this would be disputed by many specialists.

In Dr Muschaweck’s e mail (02/08/17), her views remained the same i.e. although they use mesh, this was only with big hernias or hernias with a weak tissue. She highlighted that it was then important to use the right meshes (Ultrapro Mesh, which is a light weight and big porus mesh), which ensured that the problem and risk of foreign body feeling was close to zero. She stated that they still have a lot of complaints against the laparoscopic procedures, as they see more and more problems after this technique.

Characteristics of mesh-related pain are not well described. A range of complications may arise from the materials used to make the mesh when undertaking laparoscopic inguinal hernia repair. Different procedures such as light weight mesh versus heavy weight mesh, biologic versus synthetic mesh, medical adhesive for patch fixation and the use of fibrin glue were discussed in a number of studies (Currie et al., 2012; Sajid et al., 2013; Horisberger et al., 2013; Majumder et al., 2016; Melkemichel et al., 2019; Shen et al., 2017) whereby they discussed the possible risks with each procedure.

Thus to date there are still opposing views regarding the use of mesh. While the initial outcome of surgical procedures using mesh appears to be good, there are some negative effects that have been reported. However, the magnitude of these negative consequences is not clear. Further research is needed to determine whether there are overriding benefits to using mesh. Meanwhile, this would not differentiate our approach to rehabilitation which is based on all the biomechanical mal-adaptations and overall assessment. However, this knowledge regarding mesh repair, has made me more aware of possible problems when a patient has had mesh repair and to collaborate where necessary with the Specialist if any problems develop.

7b iii. Surgical Techniques for FAI Syndrome (FAIS)

FAI (morphological changes) and any associated labral or chondral pathology which may be symptomatic (FAIS) may be a common cause of hip discomfort, particularly in young athletes. This is due to axial or torsional forces placed on the hip during high intensity sporting activities. As stated previously, the concern to date is that there appears to be an implication of the pathomechanics and morphological abnormalities of the hip leading to early OA. The goal of surgical intervention is to reduce dynamic impact between the femoral head-neck junction and the labro-acetabular complex, especially during flexion and internal rotation of the hip, as well as to address any labral and chondral lesions. There is currently no long term prospective data examining the implications of FAIS and the effects of early surgical intervention on the current pathology or later development of OA.

Arthroscopic repair was introduced in 2005 and has continued to develop since then, with the intent of providing pain relief and improving function in patients with FAI (Reiman et al., 2016). Management and surgery for FAI was well highlighted by Khan et al. (2016), whereby they questioned the variability of management of FAI and they stated that although FAI management is early in the innovation cycle, it is at a "global tipping point" toward wider uptake and use.

There has been much debate as to the merit of operating on FAI or FAIS. According to Casartelli et al. (2016), a decrease in muscle strength for hip flexors, adductors, external rotators, and abductors in patients with FAIS compared with healthy controls provides
rationale for non-surgical treatment. I totally concur with this.
Surgical results vary in studies from significant improvement (80%) (Cvetanovich et al.,2018) improvement over 5 year post-operative (Nwachukwu et al. 2020), to low return to previous level of sport (18% - Glaws et al., 2019; one third - Ishoi et al., 2018). The most commonly reported reasons for not returning to sport were weakness (69.6%), fear (65.2%), and pain (56.5%) (Glaws et al., 2019). I believe these factors are mostly reversible.

Table 15: Variability of FAI / FAIS Surgery

Author	Title	Outcome
Philippon and Schenker, (2005).	Athletic hip injuries and capsular laxity.	This review showed that 36% of professional and Olympic-level athletes who underwent hip arthroscopy **required decompression of a Cam or pincer impingement** due to repetitive hip flexion and internal rotation.
Philippon et al. (2007)	FAI in 45 professional athletes: Associated pathologies and RTS following arthroscopic decompression.	In 45 professional athletes treated for FAI, **100% had labral tears and 48% had grade IV acetabular chondral lesions**.
Alradwan et al. (2012)	Return to preinjury activity levels after surgical management of FAI in athletes.	**RTS after FAI arthroscopic surgery**. Their rate of return to the previous level of competition was **88%.**
Phillippon et al. (2012)	Outcomes 2 to 5 years following hip arthroscopy for FAI in the patient aged 11 to 16 years.	Outcome 2 to 5 years following hip arthroscopy for FAI Hip arthroscopy in the paediatric and adolescent population is a safe procedure, with **excellent clinical outcomes at 2 to 5 years** and significant improvement after surgery. However, **13% of patients did require a second procedure** for capsule-labral adhesions.
Collins et al. (2014).	Is prophylactic surgery for FAI indicated?	**1) OA is not clear** and the current literature does **not show any benefit** with **prophylactic surgical procedures in the asymptomatic population** who have radiological signs of FAI. **2.** Limited evidence suggested that **asymptomatic patients**

		who have **previously undergone total hip arthroplasty for FAI**-induced OA of the contralateral hip, are at a **significantly increased risk for early degenerative joint disease.**
Byrd et al. (2016).	FAI in adolescent athletes: Outcomes of arthroscopic management.	A high proportion improved, although only 87% actually returned to their sport. **RTS may be influenced by factors other than just the success of the procedures**.
Menge et al. (2016).	Predictors of length of career after hip arthroscopy for FAI in professional hockey players.	Professional hockey players were **able to continue playing for an average of 5.9 years after surgery**. Younger age and shorter duration of symptoms at time of surgery correlated with greater length of career and years played after hip arthroscopy.
Reiman et al. (2016).	FAI Surgery Is on the Rise-But What Is the Next Step?	Surgical decision-making should be based on clear and comprehensive indications and proper surgical candidates, for FAI correction to be defined. They concluded that one should **stop accepting morphology as pathology** and that it was **"most important not to convince two thirds of the population that they have a pathologic condition, when clearly they do not".**
Marin-Pena et al. (2017)	A review of the current situation in hip arthroscopy.	**Quality of life scores improved up to 76.6%** at one year in non-arthritic patients who underwent hip arthroscopy for FAI. 23.4% remained unchanged or became worse in the same period. Good clinical results in the medium term will **allow improvements in this technique** and increase its indications
Reiman et al. (2018).	FAI surgery allows 74% of athletes to return to the same competitive level of sports participation but their level of performance remains unreported: a systematic review with meta-analysis.	Poor outcome reporting on athletic performance post-surgery makes it **difficult to determine to what level of performance** these athletes actually perform.
Lindman et al. (2020)	5 year outcomes after arthroscopic surgery for FAIS in elite athletes.	There was a statistically significant and clinically relevant improvement regarding symptoms, hip function, quality of life, and pain 5 years after surgery. Approximately half of the cohort was still in competitive sports at follow-up, yet 77% had decreased their level of sports.

RTS: Return to Sport

Table 15 reaffirms the alternative strategies, outcomes and complexities regarding surgery for FAI / FAIS.

There is no clear consensus, or a "one-off recipe" to manage FAI/FAIS and it is currently the most topical discussion-point internationally. This issue is continuously being researched and there are many ongoing studies with different perspectives regarding the role of surgery for hip morphologies and/or FAIS and possible timing e.g. Botser et al. (2014); Byrd et al. (2016); Diaz-Ledezma and Parvizi, (2013); Dippmann et al. (2014); Gupta et al. (2014); Papalia et al. (2012); Schouten et al. (2012); Shibata et al. (2017); Siddiqui et al. (2014); Tranovich et al, (2014); Yeung et al. (2014) and Zaltz et al. (2014).

It has been shown that individuals with FAIS demonstrate impairments in hip muscle strength and dynamic single leg balance (Freke et al., 2016) and that the prevalence of cam-type morphology in elite ice hockey players is very high (Lerebours et al., 2016). Thus, as these studies show, the dilemma is as to whether these morphological abnormalities, symptomatic or not, require surgery to possibly prevent future pathologies such as OA developing. Mansell et al. (2016) performed a randomised clinical trial comparing a two-year outcome after arthroscopic surgery compared to physical therapy for FAI. They concluded that the current evidence to support both surgical and conservative interventions for FAI was based on low-level research. A recent pilot study was promising in showing that a comprehensive physical therapy program has the potential for a moderate to large positive effect on hip pain, function, and hip adductor strength (Kemp et al., 2018).
The debate ensues as to whether a structured strengthening programme could have a positive outcome without surgery. From treating athletes with morphological changes and possibly some FAIS, I have found that a specific strengthening programme addressing muscle imbalance does help. An example would be a patient of mine who was a Grand Prix motor racing driver with symptomatic hip impingement signs who undertook strengthening (and some stretching) exercises and has now returned to international racing with minimal symptoms for the past year.

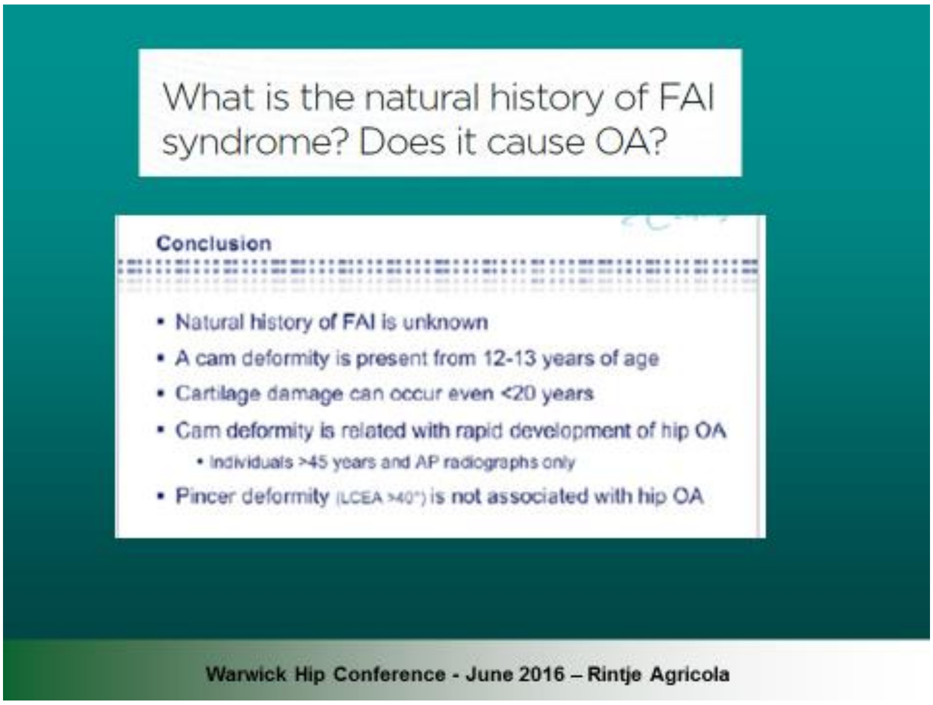
Over the past 10 years, hip morphologies and FAIS have been a major topic at many hip conferences that I have attended, as can be seen in the resultant discussions below.

Slide 174

At the Aspetar Conference (Doha, Qatar, 2014), Dr Zarco Vuchovic presented statistics of Cam and pincer morphology in athletes and explained the low prevalence of hip-related groin pain in spite of the morphological changes related to the hip. These were statistics from Qatar Stars League (Slide 174). The clinician needs to be aware of these morphological changes in the different populations (Laborie et al., 2011), sports (Philippon and Schenker, 2005: and gender (Kapron et al., 2015).

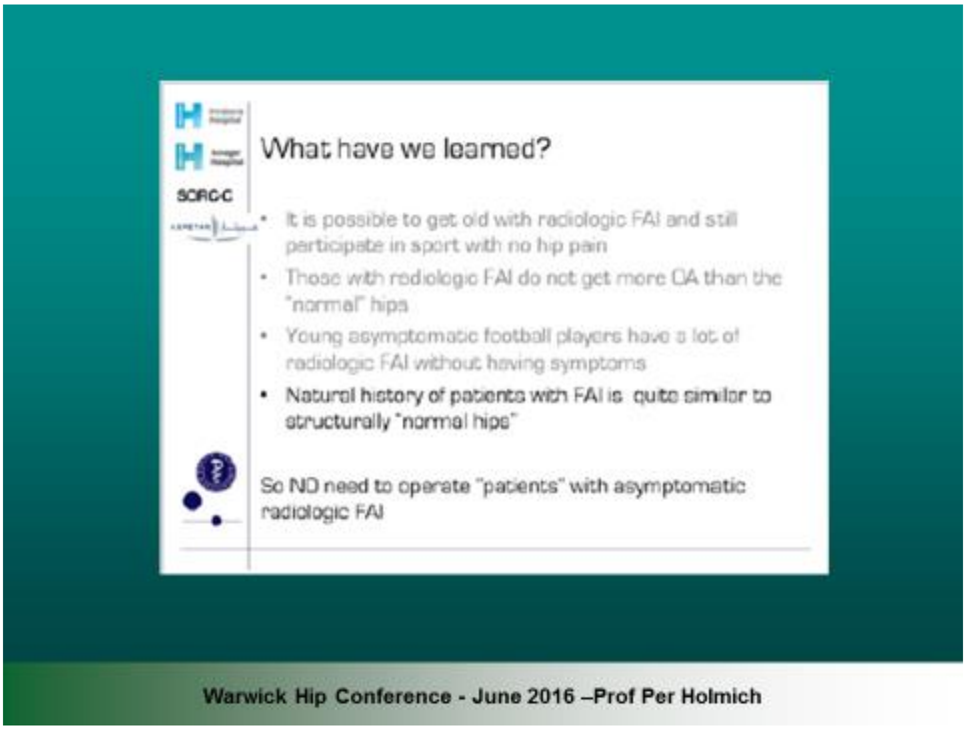
Possible surgery on asymptomatic players is constantly under discussion as it is surmised that it may prevent more serious evolving pathologies of the hip in later life, such as OA. A key point in my approach is that, as stated in Chapter 5 – Tests, implications of specific sports and within certain ethnic groups, needs to be considered and generalisation of "normal" hip movement should not be mandatory. This is a key approach to my management of hip problems.

Slide 175



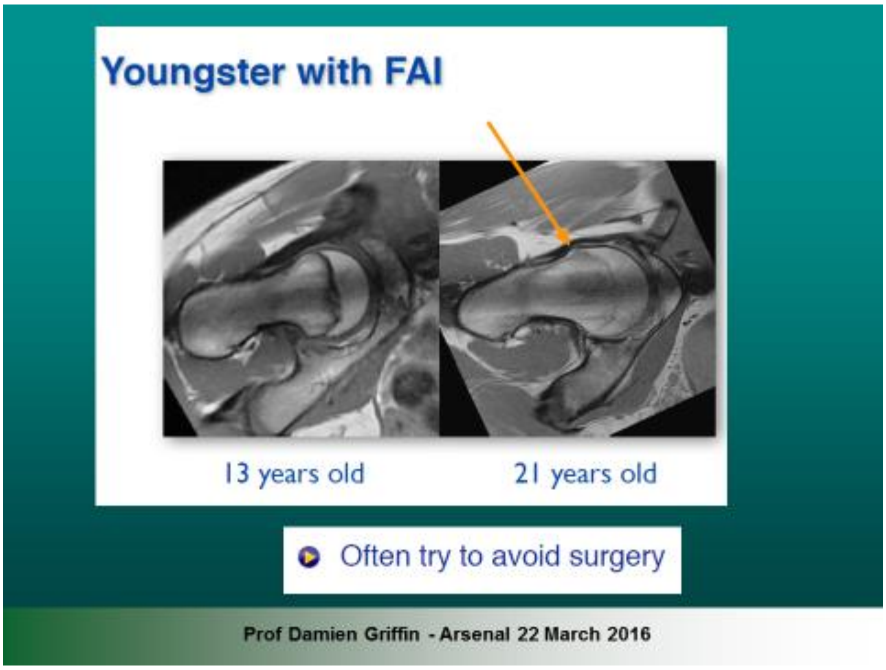
The concern amongst specialists about the long-term effect of "FAI" and the possibility of developing OA was again highlighted by Agricola at the Warwick Hip Conference in London (2016) (Slide 175).

Slide 176



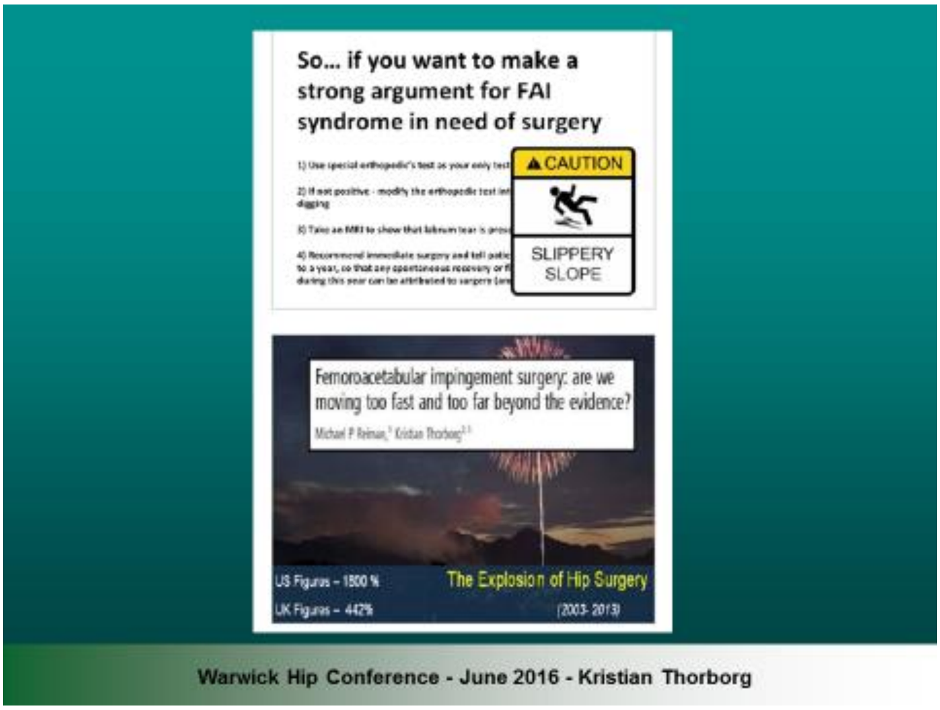
At the same conference, Holmich stated that those athletes with radiological morphological changes do not get more OA than "normal" hips. Thus he claimed that there was no necessity to operate on people with asymptomatic radiologic Cam or Pincer morphologies (Slide 176). This key point aligns with my approach and my interpretation of the literature with regards to management of hips and groin

Slide 177



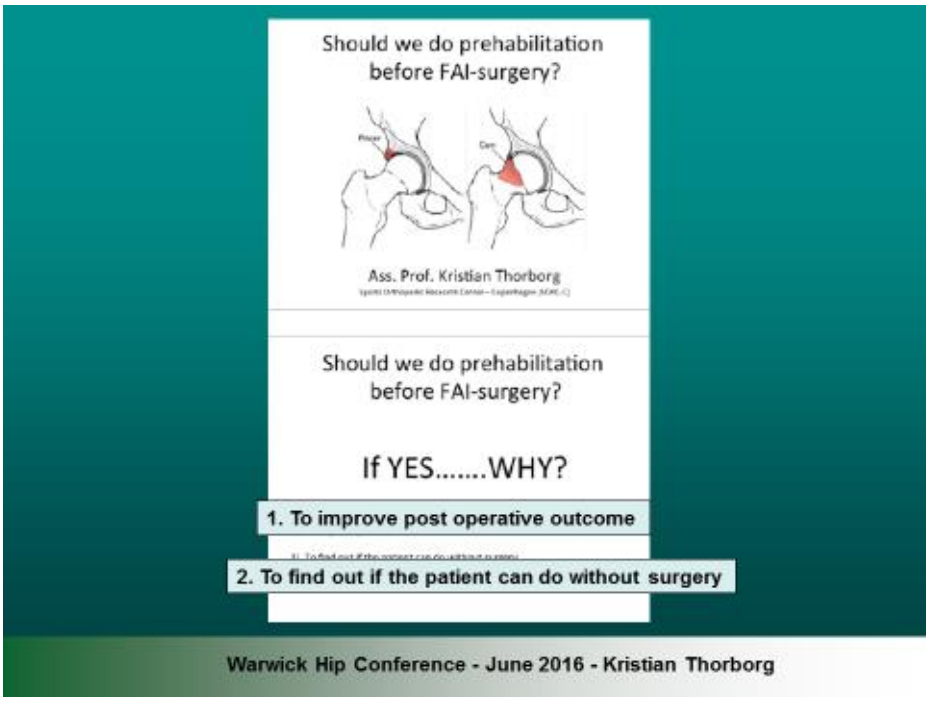
The importance of youth sports and these hip morphologies was discussed in detail at the Arsenal Conference with the possible long term consequences of hip morphological changes. It was highlighted that surgery in the youth should be avoided where possible. (Griffin, Warwick Hip Conference, St George's Park, Burton-on-Trent, Staffordshire, UK, 2016) (Slide 177).

Slide 178



Thorborg made some provocative comments regarding the "slippery slope" of FAI surgery (Warwick Hip Conference, St George's Park, Burton-on-Trent, Staffordshire, UK, 2016). (Slide 178). In particular, the fact that there has been such an explosion of discussions regarding FAIS at conferences and within studies around the world and he suggested that everyone is moving too fast with surgical procedures for FAIS.

Slide 179



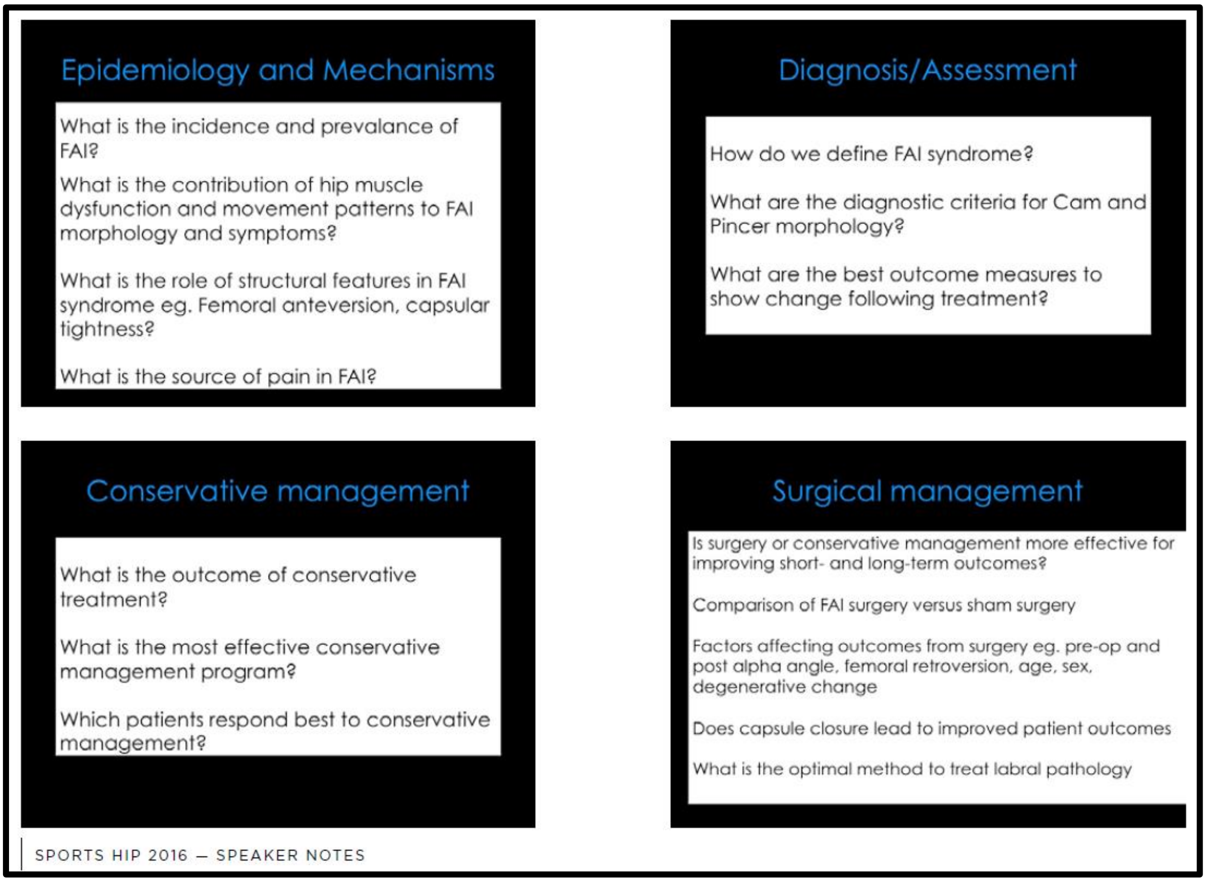
The cornerstone of this thesis is to highlight to clinicians, as suggested by Thorborg (2016), that one should do pre-habilitation before undertaking "FAI" surgery (Slide 179). This would be important not only for identifying whether the athlete requires surgery, but also as a good tool to improve the operative outcome, if necessary. I believe that this approach contributes to a solution in my professional field regarding groin and hip pathologies.

The current overview was summarised most succinctly by Reiman et al. (2016), who discussed whether "Impingement Surgery is on the rise-but what is the next step"? It was their view that specialists first need to properly understand and define the condition that they are treating. They stated that surgical decision-making for arthroscopic management of "FAI" has relied largely on clinical and radiological indications that are inconsistent and largely invalidated (as I have discussed in the 2 previous chapters). They are hopeful that results from ongoing studies will begin to become available within the next 5 years comparing hip arthroscopy to conservative treatment, as well as comparing hip arthroscopy to a sham arthroscopic hip procedure.

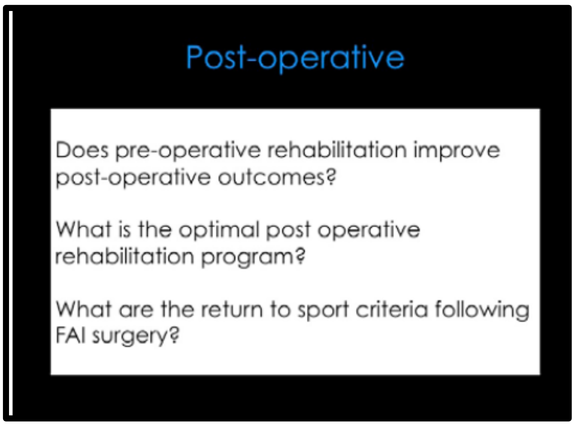
Slide 180

Mather explored the cost effectiveness of surgery for "FAI" with the outcome showing that there was no clear indication of the cost effectiveness (Warwick Hip Conference, St George's Park, Burton-on-Trent, Staffordshire, United Kingdom, 2016) (Slide 180). It is interesting that in elite sports such as Premier League Football, cost is not taken into consideration, as a "quick fix" is the main aim of management.

Slide 181



Slide 182



Excellent questions and much room for thought, were highlighted and discussed by Bennell (Warwick Hip Conference, St George's Park, Burton-on-Trent, Staffordshire, UK, 2016). While there is some evidence and many advances in the surgical treatment of FAI/FAIS, Bennell

emphasised that there are many more questions than answers (Slide 181 and 182) and a continued lack of consensus amongst all relevant medical personnel in this field of medicine. I believe it is most important for all clinicians dealing with hip morphologies or FAIS to take note of these questions and keep up to date with latest evidence based medicine, as well as connecting with colleagues. In particular, one needs far more research into the effectiveness of conservative treatment compared with surgery for hip morphologies or FAIS. I thus give my presentations to all clinicians to keep them informed of these developments and for them to hear these questions and analyse and possibly even get involved in research thereof.
As discussed by Casartelli et al. (2016), management of FAIS should possibly be a non-surgical intervention to improve dynamic hip joint stability and reduce hip pain in patients with FAIS. Thus it has been very stimulating to attend conferences such as the Hip and Groin Conference (Doha, Qatar, 2014) and Warwick Hip Conference (St George's Park, Burton-on-Trent, Staffordshire, UK, 2016) and note the significant collaboration amongst many of the highly rated expert specialists from around the world who are trying to resolve this complexity of FAIS and whether one should operate on an asymptomatic Cam or pincer morphology in order to prevent the possibility of any adverse reactions developing e.g. FAIS, labral or chondral damage or OA. Despite much discussion, however, there still appears to be limited consensus with regards to surgery and hip morphologies /FAIS.

<u>7b iv. Labral Surgery</u>

As shown in Chapter 3 - Anatomy, the acetabular labrum is an important structure that plays a significant proprioceptive role in efficient biomechanical function and stability of the hip joint. Traumatic instability is associated with sports such as skiing, rugby, biking, football and soccer while traumatic instability is usually associated with hip dysplasia and connective tissue disorders (Marin-Pena et al., 2017). Labral tears in patients less than 25 years of age occurs commonly without bony deformities, with those with normal head/neck contour demonstrating significantly less early cartilage damage than those with bony pathology (Bayley et al., 2017). They explained that from 2005 to 2013, 82 hips in 76 patients with mean age of 20.4 years underwent hip arthroscopy for treatment of labral-chondral damage. The authors concluded that hip arthroscopy in young patients can improve function and quality of life with minimal morbidity.

The initial rationale for labral debridement was to restore the suction-seal function of the hip joint (Zaltz, 2012). The surgical procedure of the resection of a torn labrum has subsequently changed over the past few years. Different studies have reported using several labral management techniques such as debridement, labralization, looped suture fixation, base stitch fixation, inversion-eversion, and reconstruction. The optimal technique is yet to be determined by hip surgeons (Kollmorgen and Mather, 2017). There appears to be consensus that an absolute indication for labral repair was symptomatic intra-articular pain, joint space >2 mm, and failed conservative management. The understanding of FAI and labral function is continuously evolving and thus labral preservation surgery continues to advance. It is now mandatory that labral preservation is to be recommended when possible, to ensure restoration of suction seal, stability, and contact pressure of the hip joint. Thus arthroscopic labral debridement, as opposed to resection, has been shown to be an effective and safe procedure that provides good short-term clinical outcome in hips (Anwander et al., 2017; Ayeni et al., 2014; Domb et al., 2014 and Menge et al., 2017).

An interesting observation was made by Chandrasekaran et al. (2017), showing that the pattern of labral injury was different in males and females and subsequently dictated the arthroscopic approach. Females are likely to require a capsular plication and iliopsoas release to address soft-tissue laxity and impingement. Further, Litrenta et al. (2019) believed that hip arthroscopy for the treatment of labral tears in adolescents remains a technically challenging procedure that should be approached with appropriate caution as its safety and efficacy in the adolescent population have been controversial.

Locks et al. (2017), discussed that although the outcomes after hip arthroscopy were directly related to labral preservation, a primary labral repair may be challenging in certain cases in which there is insufficient tissue to perform a primary repair. They describe an arthroscopic hip labral augmentation technique using iliotibial band autograft or allograft, while preserving as much labral tissue as possible.

Return to sports after labral surgery has not been well documented. Mohan et al. (2017) declared that athletes return to sports at a high rate (92%) after hip arthroscopy and perform activities at near preinjury levels. In this group of athletes, arthroscopic labral repair with chondro-labral preservation, which reflected less severe chondro-labral pathology, performed better than labral repair with takedown and reattachment.

At the Warwick Hip Conference (Warwick, UK, 2010), I asked the question to the panel of Specialists, as to whether an asymptomatic labral tear shown on a screening programme for elite athlete should or should not be operated on prophylactically. The response was an outcry from the UK specialists against this suggestion, but was supported by an eminent USA hip specialist who explained that medico-legal implications come into play if surgery was not performed and a top National Football League player broke down during the season. However, subsequent interactions with medical personnel since that conference has shown a move away from prophylactic intervention, with which I totally concur and would personally recommend a specific strengthening protocol rather than surgery where possible.

7b v. Surgery for Chondral Lesions

Hip pain remains a challenge due the multiple factors that can cause damage to the articular cartilage, such as traumatic injury, metabolic damage and morphologic variations.

Chondral lesions are common and several classification systems exist to classify them based on severity, location, radiographic parameters, and potential treatment options. The outcome of the study by Makhni et al. (2017), was that patients with articular cartilage lesions of the hip had arthroscopic operative treatment which decreased morbidity and offered innovative solutions. Currently, chondroplasty, microfracture, cartilage transplants (osteochondral autograft transfer, mosaicplasty, osteochondral allograft transplantation) and incorporation of orthobiologics are some techniques that have been successfully applied to address chondral pathology in the hip. Further refinement of these modalities and research in novel techniques continues to advance a surgeon's ability to address chondral lesions in the hip joint (Dallich et al. 2019).

7b vi. Hip Capsule Repair

Arthroscopic hip capsular repair is another area of great interest. Basic science studies suggest that adverse changes in capsular stability/restraint may occur with capsulotomy and capsulectomy and repair may ameliorate these changes. Clinical studies suggest that in some conditions, most notably mild dysplasia, capsular repair or plication may improve short-term outcomes. However, in general, the role of capsular closure is less clear (Matsuda, 2017). Chahla et al. (2017) discussed the clinical relevance regarding re-establishing the native anatomy of the hip capsule after hip arthroscopic surgery which may result in improved outcomes and reduce the risk of iatrogenic instability. They emphasised that adequate capsular closure was important to restore proper hip biomechanics, and postoperative precautions limiting external rotation should be utilized to protect the repair. It would be meaningful to do studies related to athletes in their respective sports.

The question was raised in an editorial as to whether hip joint surgeons should repair the capsule and whether this was anatomical vandalism of the hip. The query was regarding any beneficial effects in long-term clinical follow-ups. They concluded that hip capsular repair seems a sound adjunct to hip arthroscopic surgery to date (van Arkel et al., 2017). This debate continues.

7b vii. Iliopsoas Repair

Disorders of the Iliopsoas can be a significant source of groin pain in the athletic population. Commonly described pathologic conditions include Iliopsoas bursitis, tendonitis, impingement, and snapping. The first-line treatment for Iliopsoas disorders is typically conservative. Surgical treatment can be considered if the patient fails conservative measures and usually involves arthroscopic lengthening of the musculo-tendinous unit and treatment of concomitant intra-articular abnormality. Tendon release has also been described (Anderson, 2016).

Iliopsoas tendinopathy can be associated with FAI in some patients, and failure in diagnosing and treating may be the reason of poor results and a revision surgery. The aim of a study by Mardones et al. (2016) was to report the results of a 4-year follow-up of a series of patients affected by FAI and an associated Iliopsoas tendinopathy and treated with hip arthroscopy and transcapsular tendon release. The outcome was that arthroscopic Iliopsoas tendon release seems to produce good clinical outcome, reducing pain and the rate of a revision surgeries. However, caution regarding surgery for Iliopsoas was highlighted in two studies. Brandenburg et al. (2016) concluded that arthroscopic Iliopsoas release resulted in Iliopsoas atrophy with a 25% volume loss and a 19% reduction in seated hip flexion strength. I personally have not treated many Iliopsoas tendinopathy releases. Those few that I have rehabilitated post-surgery have had positive outcomes and returned to their sport. Chalmers et al. (2017) discussed Iliopsoas impingement after primary total hip arthroplasty as a potential cause of persistent groin pain and concluded that non-operative management of Iliopsoas impingement led to groin pain resolution in 50% of patients. In patients with minimal acetabular component prominence, Iliopsoas release provided a high rate of success. Further, tenotomy for Iliopsoas tendinopathy after hip arthroplasty, whether performed endoscopically or arthroscopically, provided good outcomes in over 85% of patients, usually with full recovery of hip flexor strength over time. Thus overall, surgical intervention for Iliopsoas pathology appears to have a positive outcome (May, 2019).

7b viii. Gluteus Medius / Gluteus Minimus Repair

High-grade partial articular gluteus tendon avulsion can occur as either an isolated Gluteus Medius tear, an isolated Gluteus Minimus tear, or a combination of both. The purpose of an article by Nho et al. (2016) was to guide orthopaedic surgeons in the recognition of this Gluteus tendon avulsion with MRI and dynamic examination to allow for accurate repair. Traditionally, the surgical intervention for Gluteus Medius repair has been carried out through an open technique with good results. However, advantages of endoscopic techniques have been endorsed by Domb et al. (2010), Chandrasekaran et al. (2015), Lerebours et al. (2016) and Mosier et al. (2016). Thaunat et al. (2016) concluded in their study that the degree of tendon degeneration may compromise the tissue left for reattachment, raising concerns over its healing capacity, durability, and ultimate strength of the repair. However, overall, the endoscopic repair appears to give satisfactory results which need to be confirmed by clinical studies with longer follow-up.

7b ix. Ligamentum Teres Repair

Ligamentum Teres injuries or tears have been said to be a common cause of groin discomfort and pain, and they have been identified in 8–51% of patients undergoing hip arthroscopy (Portos and O’ Donnell, 2015). There is lack of consensus regarding indications for Ligamentum Teres reconstruction and the absence of long-term results. The importance of Ligamentum Teres and the various classification systems have been discussed in Chapter 3 - part 2. O’ Donnell’s Ligamentum Teres tear classification (2015) was based on direct arthroscopic observation and dynamic rotational manoeuvers of the hip. These movements allow visualization of some tears, which had not been identified during static observation and also allow identification of areas of Ligamentum Teres impingement against bone or articular cartilage. However, Devitt et al. (2017)

found that there was minimal reliability of commonly used arthroscopic classifications of Ligamentum Teres pathology and possible surgical intervention.
These ongoing studies on Ligamentum Teres management are vital as the growing knowledge of the importance of the Ligamentum Teres becomes apparent. In their systemic review, De Sa et al. (2014) concluded that Ligamentum Teres debridement is indicated for short-term relief of hip pain caused by partial-thickness tears (type 2) and failing conservative management, whereas reconstruction with autografts, allografts, or synthetic grafts may be indicated for full-thickness (type 1) Ligamentum Teres tears that cause instability or have failed previous debridement, or a combination of these conditions. Other successful surgical procedures for Ligamentum Teres were demonstrated in studies by Amenabar and O'Donnell, 2013; Haviv and O'Donnell, 2011 and Philippon et al., 2012. The Ligamentum Teres gives stability in limiting internal rotation during sports such as martial arts, ballet, soccer, golf and kicking in American football and thus the preservation is most important. When compared with Ligamentum Teres reconstruction, patients treated with arthroscopic debridement achieved better clinical scores (Marin-Pena et al., 2017). More studies involving an athletic population would be most useful.

The implications of the injury / absence of this ligament in the hip is most important for rehabilitation and in particular, prevention of hip pathologies. If on a pre-screening evaluation a Ligamentum Teres tear is identified, it is my clinical opinion that depending on the grade of tear, an intensive hip stabilising protocol may prevent a surgical procedure. This would also depend on various factors, in particular the type of sport played. However, more research is needed investigating the effectiveness of conservative rehabilitation programmes versus surgical intervention.

7c. Overview: Surgical Procedures

Hip arthroscopy is an established intervention for the treatment of hip pathologies in the sporting and general population and has become increasingly common worldwide as advances have been made in the understanding of the pathophysiology of hip injuries, as well as technological advances in arthroscopic surgical techniques and instrumentation (Malviya et al., 2012). In their study assessing adults diagnosed with longstanding groin pain with no hernia, Jorgensen et al. (2019) found that surgery seems to be more efficient in returning the patients to habitual activity, reducing their pain, and satisfying them compared to conservative treatment.

Once again, it would be useful if they could have undertaken the study analysing the athletic population. Previously, Meyers et al. (2007) explained that some initial mistakes attributing the cause of the injuries to occult hernias led to many unsuccessful operative repairs and a general surgical dogma against surgery for undefined abdominal or groin pain.

Conditions which were previously treated with open surgery are now frequently managed with arthroscopic intervention, such as removal of loose bodies, chondral injury, labral injury, “FAI”, snapping hip and Gluteus Medius tears. Barastegui et al. (2017) and Lee et al. (2016) declared that hip arthroscopy was a relatively safe procedure with good return to play outcomes. However, De Sa et al. (2016) concluded that given the complex anatomy, equal intra-articular and extra-articular contribution and potential for overlap of clinical entities causing groin pain leading to surgery in athletes, further studies were required to ascertain more certainty. In future, long-term clinical results after the treatment of these new hip pathologies will demonstrate whether hip arthroscopic techniques are a trend or a real advance (Marina-Pena et al., 2017). It is precisely because of these complexities that my management approach is aimed at providing a solution.

From the rehabilitation point of view, the concern is that the current literature of post hip arthroscopy rehabilitation lacks high-quality evidence to support a specific protocol (Grzybowski et al., 2015). Future studies are required. Effective return to sport requires analysis as to whether the surgery was effective, or the rehabilitation or the time off before returning the sport? It may even be a complex relationship between all 3 factors. This where my approach endeavours to find a solution.

King et al. (2015) undertook a systematic review and meta-analysis of surgical versus physical therapy rehabilitation outcomes in athletic groin pain in order to compare the return to play rate and return to play time and concluded that there were better outcomes with rehabilitation for pubic-related groin pain, with no difference between the adductor and abdominal groups. However, they highlighted the poor quality and risk of bias in the literature making accurate comparison difficult. Thus although one cannot take this outcome as a given, I still believe that in spite of the research discrepancies, physical therapy has shown to be the positive protocol in my professional experience.

The following studies demonstrate different strategies for surgical intervention and include Ali et al. (2013); Amato et al. (2012); Andresen et al. (2014); Bansal et al. (2013); Bracale et al. (2012); Irshad et al. (2001); Kluin et al. (2004); Lange et al. (2015); Li et al. (2013); Malekpour et al. (2008); Meyer et al. (2013); Ray et al. (2014); Timisescu et al. (2013); Verhagen et al. (2017); Wang et al. (2013) and Zwaans et al. (2015).

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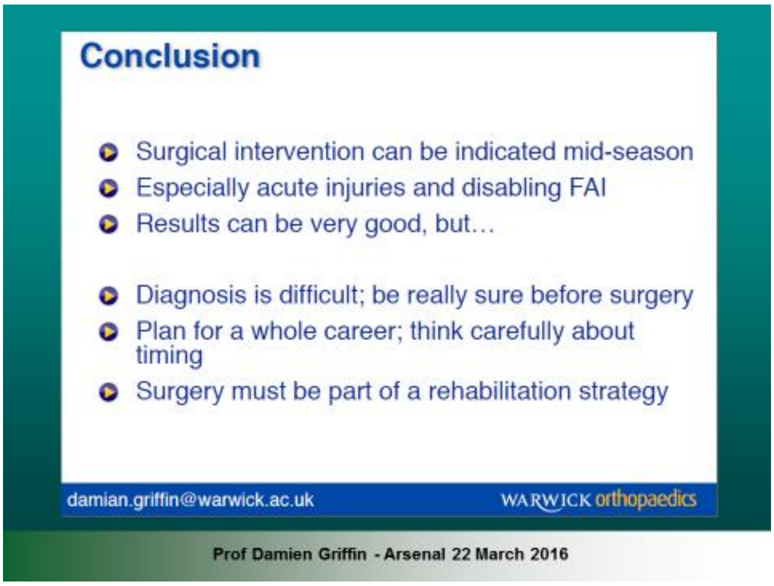

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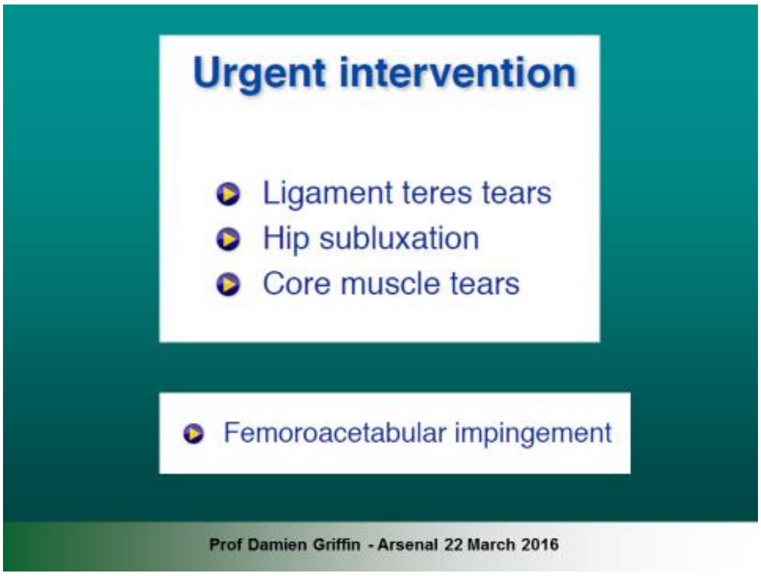


As shown on Slides 183 and 184 from the Arsenal Conference (London, United Kingdom, 2016), Griffin gave a succinct conclusion on whether surgical intervention is required and when it becomes a necessity e.g. for Ligamentum Teres tears, hip subluxation and core muscle tears

These factors are clinically very relevant and should be noted by all practitioners.

One of the main controversies among different treatment centres is whether young, asymptomatic patients with morphological changes of the hip joint should undergo prophylactic surgical treatment. As discussed previously, their management is currently under debate and unresolved. I personally feel that it is not an option to have prophylactic surgery, as I believe that a specific strengthening programme would have a more positive outcome in strengthening the relevant muscles and thus possibly preventing symptomatic pathologies from developing. Further long term follow-up will reveal whether the clinical benefits of hip arthroscopy are maintained and whether it is cost effective in the long term (Griffin et al., 2018).
From my physiotherapist perspective, it would be good for surgeons to have the knowledge of functional implications of their surgical intervention. To this end, I have given a few presentations to orthopaedic surgeons on this aspect, which have been well received by surgeons/researchers such as Mr Gilmore (Gilmore Groin and Hernia Clinic, Harley St, Marylebone, London, 2013) and Orthopaedic Surgeons at Groote Schuur Hospital, University Cape Town South Africa, 2018).

Conclusion – Surgical Procedures

Guidelines for groin hernia management was developed by an expert group of international surgeons (HerniaSurge Group, 2018). According to these experts, more than 20 million patients undergo groin hernia repair annually around the world with many different approaches, treatment indications and a significant variation of techniques. There were concerns about the complication of chronic pain which still occurs in 10–12% of patients. They believe that more knowledge, better training, national audit and specialization in groin hernia management may standardize care for these patients and thus lead to more effective and efficient healthcare and provide direction for future research. I am somewhat bemused by the nomenclature “hernia repair,” as I wonder as to the specificity of the variable pathologies involved, when one discusses “hernia repair.” Although the surgeons may have had a specific hernia pathology in mind, many clinicians would be confused by the exact meaning of this hernia diagnosis. Further, it would be useful to have more research specifically on athletes in different sporting domains.

There is not much research to guide protocols for pre-habilitation or post-operative rehabilitation and there is significant variation among the post-surgery rehabilitation protocols which may affect the perceived success or failure of the surgery. Further, a very specific time period should be highlighted in order to prevent the "quick fix" that seems to be the intervention of choice in a number of elite sports.

Working with 20 Premier League Football clubs for 13 years and collating medical evidence from each club, it has been most interesting to observe the different surgical procedures and different outcomes for various diagnoses. As has been discussed, so much is dependent on the specific diagnosis and consequential referral to the surgeon who deals only with that particular diagnosis. Thus the dilemma for the respective physicians who recognise the multifactorial and complex nature of the differential diagnosis.

The take-home message for all clinicians should be to continuously explore all new information on the ongoing saga of surgical procedures and I would propose that every athlete should have specific groin/hip exercises as a matter of course as a prevention strategy.

Chapter 8: Rehabilitation

8a. Background

Conservative management of groin and hip pain remains a highly debated topic. Holmich (1999) found that active physical training was found to be very effective in the treatment of athletes with Long standing adductor-related groin pain, but Machotka et al. (2009) declared that there was no clear evidence regarding the most effective intensity and frequency of exercise.

As discussed previously, background knowledge of anatomy, functional anatomy and individual sports is the basis for organising a rehabilitation strategy for athletes with groin and/or hip pain e.g. Dickenson et al. (2016); Eirale et al. (2014) and Menge et al. (2016).

Slide 185

Table 1 Summary of final consensus recommendations developed from evidence synthesis for voting at consensus meeting and recommendation of consensus group

	Consensus recommendations for clinical practice	Level of evidence supporting recommendation	Median	IQR	Mode	Consensus score result	Number participants voting
C1.	Exercise-based treatments are recommended for people with hip-related pain.	Moderate[5,12,14]	9	8–9	9	Appropriate	37
C2.	Exercise-based treatment should be at least 3 months duration.	Limited[14]	7	7–8	7	Appropriate	37
C3.	Physiotherapist-led rehabilitation after hip surgery should be undertaken.	Limited[13,18]	9	8–9	9	Appropriate	37
C4.	PROMs, measures of physical impairment and measures of psychosocial factors should be used to monitor response to treatment.	Insufficient	9	8–9	9	Appropriate	37
C5.	Physical activity (which may include sport) is recommended for people with hip-related pain.	Insufficient	9	8–9	9	Appropriate	37
C6.	Clinicians should discuss patient expectations, use shared-decision making and provide education.	Insufficient	9	8–9	9	Appropriate	37
	Consensus recommendations for Research	**Level of evidence supporting recommendation**	**Median**	**IQR**	**Mode**	**Consensus score result**	**Number of participants voting**
R1.	Reporting of exercise programmes. Exercise descriptors such as: load magnitude, number of repetitions and sets, duration of whole programme, duration of contractile element of exercise, duration of one repetition, time under tension, rest between repetitions, range of motion through which the exercise is performed and rest between exercise sessions should be reported.	Moderate[4,5,12,14]	9	9	9	Appropriate	36
R2.	Development of high-quality exercise programmes. We need research to investigate the optimal frequency, intensity, time, type, volume and progression of exercise therapy.	Moderate[4,5]	9	7–9	9	Appropriate	28
R3.	Research should examine the effect of patient education in people with hip-related pain.	Insufficient*	8	7–9	9	Appropriate	36
R4.	Research should investigate the effect of other treatments used in people with hip-related pain.	Insufficient*	8	8–9	9	Appropriate	35
R5.	Research should examine the impact of comorbidities and social determinants on treatment effectiveness in people with hip-related pain.	Insufficient*	9	9	9	Appropriate	36

Scores 0–3 were considered inappropriate, scores of 4–6 were considered uncertain and scores of 7–9 were considered appropriate.
Not all participants were able to be present for all voting procedures due to other commitments.
*Absence of knowledge noted and prioritised as area for future research by expert group.
C, Consensus recommendation for clinical practice;PROMs, patient-reported outcome measures; R, consensus recommendation for research.

Kemp JL, *et al. Br J Sports Med* 2019;**0**:1–8. doi:10.1136/bjsports-2019-101458 3

Slide 185 describes the Consensus recommendations from the international hip-related pain research network in Zurich (2018), This highlighted the fact that there was limited or insufficient evidence regarding management of hip pain and moderate evidence for exercise intervention for hip related pain (Kemp et al., 2019). Minimal evidence supporting the use of exercise in the treatment of groin pain was highlighted by Jorgensen et al., 2016; Kemp et al., 2013; Verrall et al., 2007; Weir et al., 2009, 2010 and 2011.

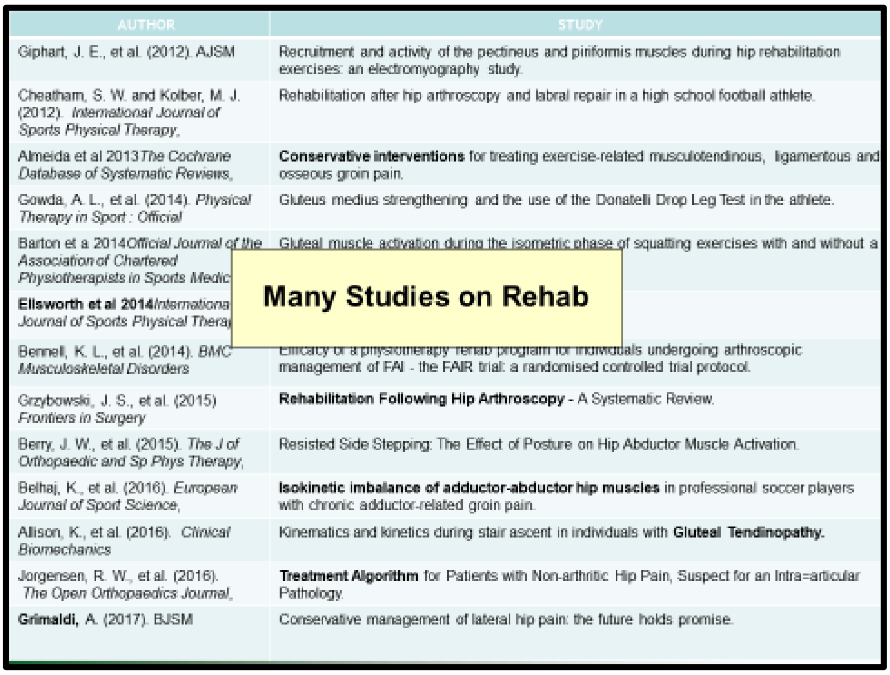
Generally, reviews have failed to reach a consensus on the efficacy of a rehabilitation. In many cases the quality of studies is poor, which limits the interpretation of findings (Almeida et al., 2013; Barratt et al., 2016; Grimaldi, 2015, 2017; Serner et al., 2015).

Charlton et al. (2017) stated that exercise interventions for the treatment and prevention of groin pain in athletes are poorly described, especially with respect to use of external load and methods of progression. Once again, I believe that clinicians need to be very aware of all the research, while at the same time analysing their approaches and critically assessing the outcomes. In this instance I would most definitely continue my management of the athlete with awareness of load and specific progression, both of which is highly individualised.

It appears that exercise rehabilitation may be effective when incorporated as part of an integrated treatment protocol (Maffey et al., 2012 and Mellor et al., 2016). However, exercise interventions for the treatment of groin injury are generally poorly described (Charlton et al., 2017). Ramazzina et al. (2019), shed some light on common key aspects able to improve the typical signs of groin pain, but on the basis of available data they were unable to provide practical guidelines. Further studies are necessary to set the best treatment algorithm for the management of groin pain in athletes.

As the evidence for rehabilitation is far from conclusive, clinicians are required to use both existing evidence and clinical experience with constant monitoring to ensure successful treatment. Equally, prevention of groin problems and possibly the risk of developing OA in later years, is possible with a greater understanding of normal hip and pelvis physical function and resultant targeted exercise programme. Further, the quandary regarding physical therapy versus surgical intervention is an ongoing point of discussion (Thorborg - Aspetar Conference, 2014 and King et al., 2015).

Slide 186

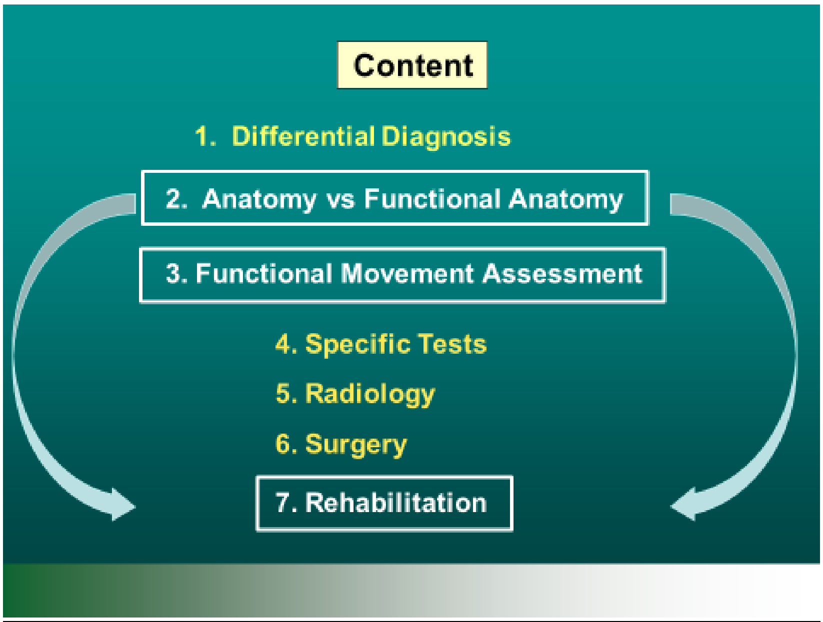


AUTHOR	STUDY
Giphart, J. E., et al. (2012). AJSM	Recruitment and activity of the pectineus and piriformis muscles during hip rehabilitation exercises: an electromyography study.
Cheatham, S. W. and Kolber, M. J. (2012). *International Journal of Sports Physical Therapy*,	Rehabilitation after hip arthroscopy and labral repair in a high school football athlete.
Almeida et al 2013 *The Cochrane Database of Systematic Reviews*,	**Conservative interventions** for treating exercise-related musculotendinous, ligamentous and osseous groin pain.
Gowda, A. L., et al. (2014). *Physical Therapy in Sport : Official*	Gluteus medius strengthening and the use of the Donatelli Drop Leg Test in the athlete.
Barton et a 2014 *Official Journal of the Association of Chartered Physiotherapists in Sports Medic*	Gluteal muscle activation during the isometric phase of squatting exercises with and without a
Ellsworth et al 2014 *Internationa Journal of Sports Physical Thera*	
Bennell, K. L., et al. (2014). *BMC Musculoskeletal Disorders*	Efficacy of a physiotherapy rehab program for individuals undergoing arthroscopic management of FAI - the FAIR trial: a randomised controlled trial protocol.
Grzybowski, J. S., et al. (2015) *Frontiers in Surgery*	**Rehabilitation Following Hip Arthroscopy** - A Systematic Review.
Berry, J. W., et al. (2015). *The J of Orthopaedic and Sp Phys Therapy*,	Resisted Side Stepping: The Effect of Posture on Hip Abductor Muscle Activation.
Belhaj, K., et al. (2016). *European Journal of Sport Science*,	**Isokinetic imbalance of adductor-abductor hip muscles** in professional soccer players with chronic adductor-related groin pain.
Allison, K., et al. (2016). *Clinical Biomechanics*	Kinematics and kinetics during stair ascent in individuals with **Gluteal Tendinopathy.**
Jorgensen, R. W., et al. (2016). *The Open Orthopaedics Journal*,	**Treatment Algorithm** for Patients with Non-arthritic Hip Pain, Suspect for an Intra=articular Pathology.
Grimaldi, A. (2017). BJSM	Conservative management of lateral hip pain: the future holds promise.

There are many studies discussing possible strategies for rehabilitation of groin and hip pain (Slide 186). Most importantly there is no set “recipe,” as there are so many variables involved. This is a constant fact that I explain to attendees at my presentations who attend the presentations with the expectation of being given a one-size-fits-all recipe for rehabilitation of the groin and hip.

This chapter aims to present all aspects of rehabilitation and the evidence behind it. Further, in spite of the dearth of specific rehabilitation exercises, it does demonstrate the efficacy of exercises for groin and hip pain. I strongly believe that from analysing these studies, as well as from my experience, prevention and rehabilitation of groin and hip pain is feasible. Since undertaking this professional PhD, I have learnt so much and I have observed the positive effects of my rehabilitation on my athletes, which was not always the case previously. Hence I do believe that my approach may provide a solution to the groin and hip complexities.

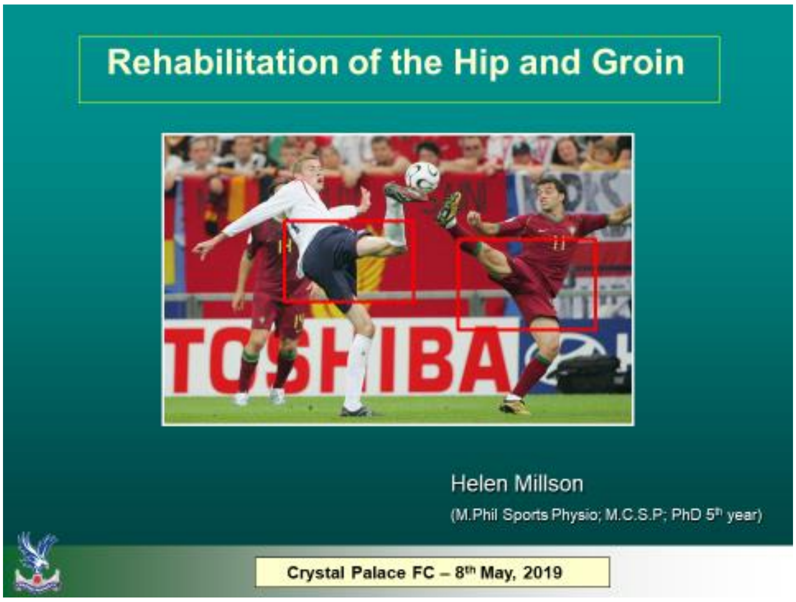
Slide 187



Slide 188

Although a proper diagnosis would be the obvious starting point to effective rehabilitation, it is possible to rehabilitate groin and hip problems without a specific diagnosis. This can be done with a thorough knowledge of functional anatomy, a very specific and detailed functional assessment, and identifying any mal-adaptations regarding the entire kinetic chain and its functionality (Slide 187 and Slide 188). This is the cornerstone of my approach in this thesis.

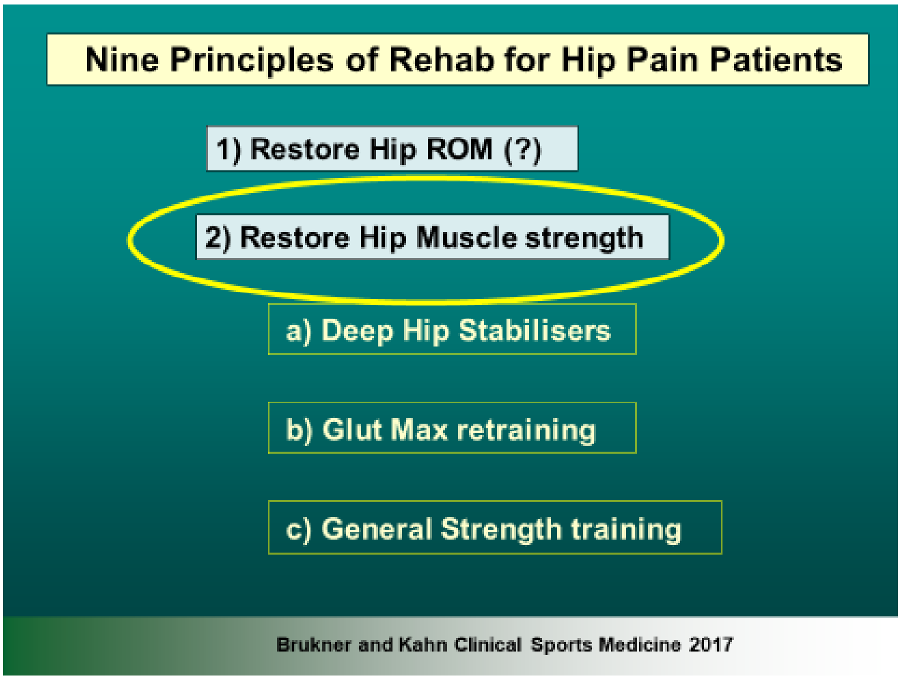
Slide 189



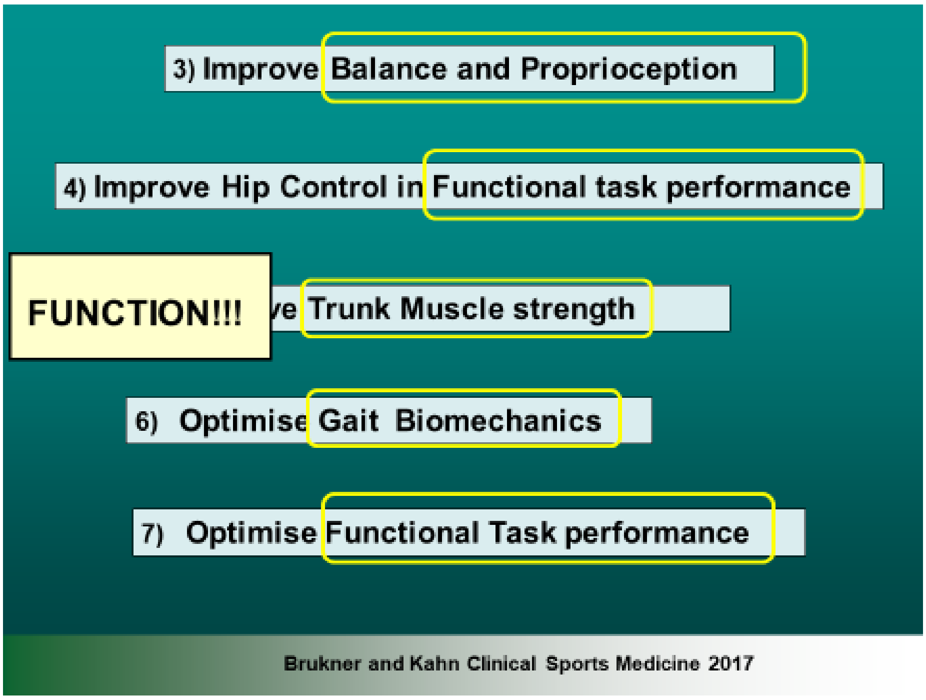
Injuries to the hip and groin can vary significantly depending on the specific sporting activity involved. Thus analysing the kinetic movement of each individual athlete and his/her particular requirements of the sport / activity may be undertaken for useful rehabilitation

Slide 189 gives a visual example on the extraordinary loads on the pelvic/groin /hip area, in this case being football. Each patient must thus be managed individually when organising a rehabilitation strategy.

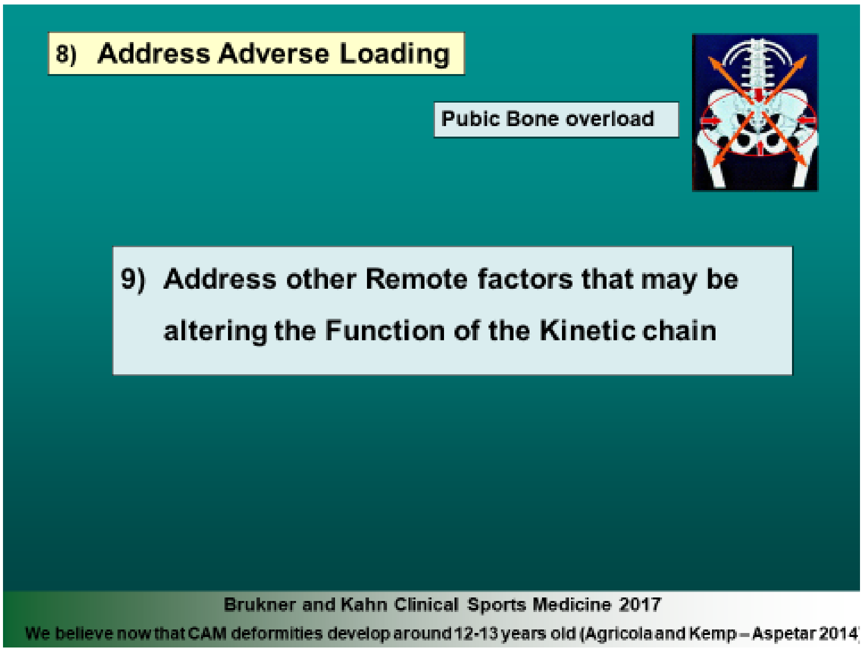
Slide 190



Slide 191

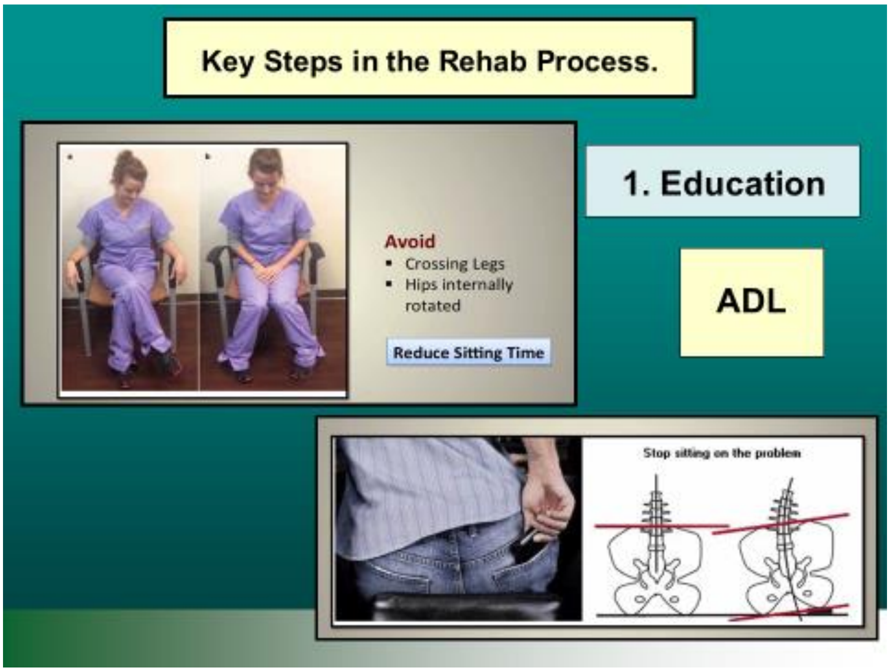


Slide 192



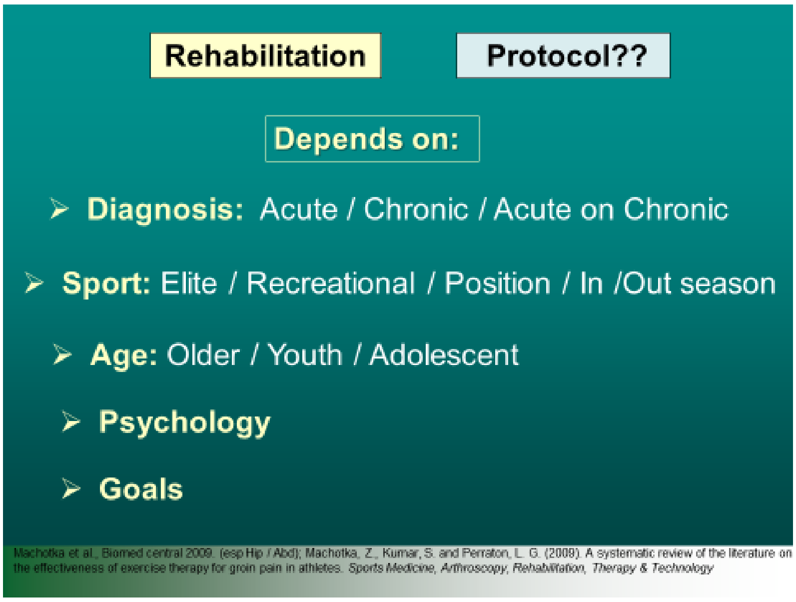
As described by Brukner and Kahn (2017), there are 9 basic principles of rehabilitation for hip pain patients (Slides 190, 191 and 192). Most significantly, these 9 principles are very much based on functionality, as can be noted on the slides above, which historically never used to be the case. This has been the cornerstone to my approach to hip and groin management over many years and forms the basis of my presentations.

Slide 193



What is not mentioned, but is a critical part of managing an athlete with groin or hip pain, is the individual's activities of daily living. As shown in Slide 193, assessment and consequential education of the athlete as to their activities of daily living (including sleeping), is most important. In many cases, the diagnosis and the cause of the pain is described by the use of clinical tests or radiological imaging, specific to the groin or hip and the athlete's sporting activity. However, I have found that in clinical practice the cause of pain may often not be related to their sport at all, but based on their incorrect, sustained or loaded activities of daily living patterns. A similar argument can be made for gym training as I observed with the Stormers rugby, where their particular gym exercise caused groin or hip pain. Thus I believe that an in-depth assessment related to their daily activites is critical and has most definitely been an important part of my management.

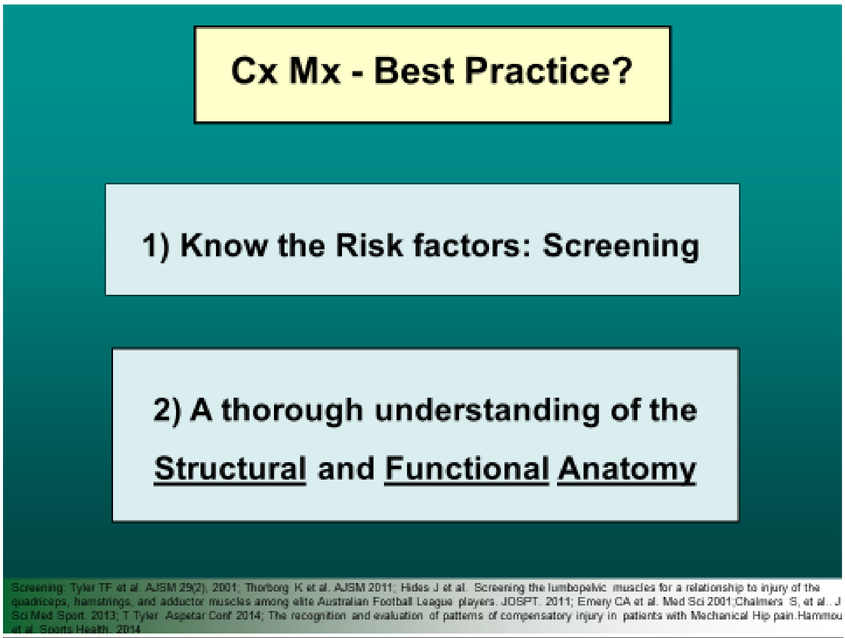
Slide 194



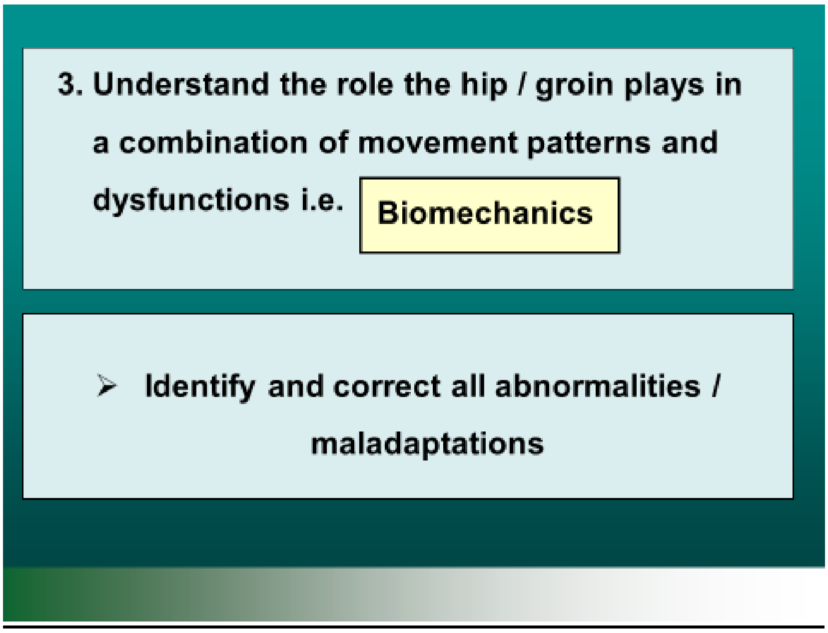
Further, certain factors play a significant role when planning rehabilitation and return to sport. Rehabilitation will differ depending on whether it is pre-season, in- season or off-season, as well as the variable factors such as the type of injury, the sports and specific demands, the age of the athlete, the individual psychology and the respective goals of the athlete (Slide 194).

8b. Rehabilitation - Aims

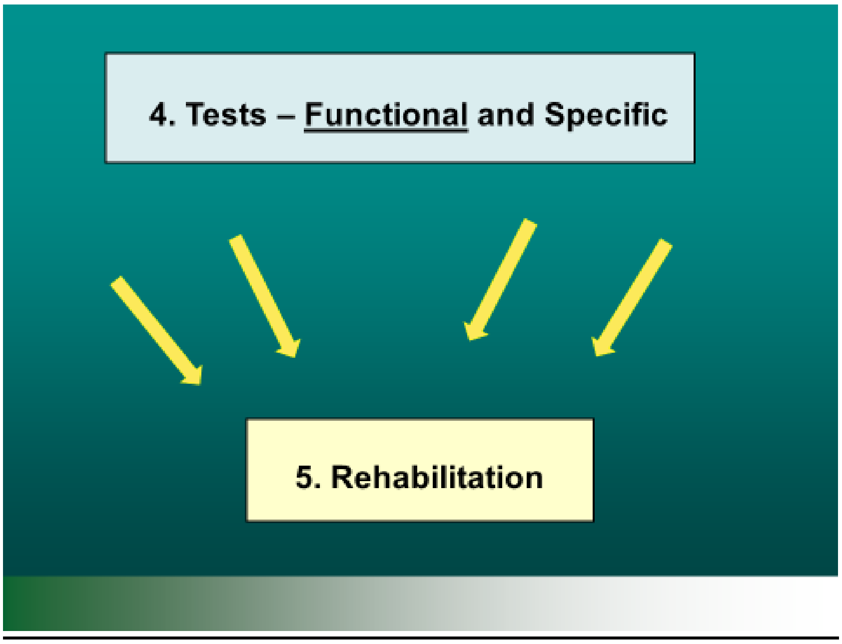
Slide 195



Slide 196



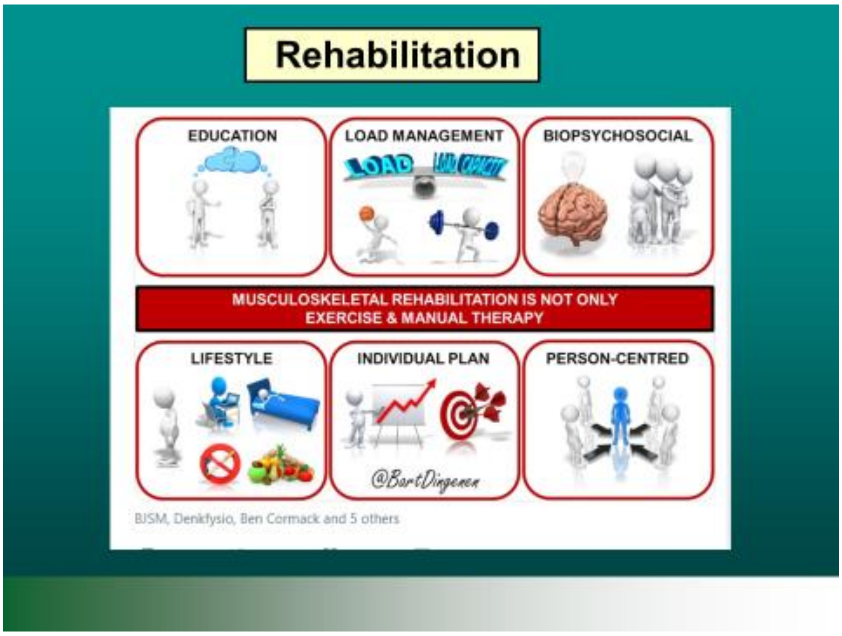
Slide 197



The 4 points shown in Slides 195, 196 and 197, are the basic principles needed to plan a successful rehabilitation protocol.

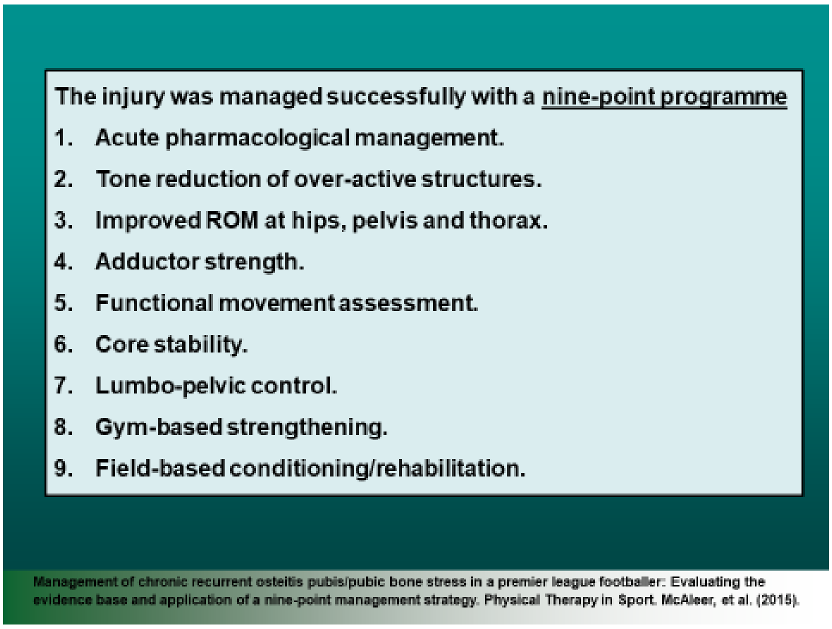
8c. Stages of Rehabilitation protocols

Slide 198



Before I discuss the different protocols for rehabilitation, Slide 198 shows an overview which is not just about exercise and is also highly individualised by going into each person's different social and biopsychosocial background. This may take more time and clinician input, but I believe my many positive outcomes for treating groin and hip pathologies are due to the inclusion of the points above and individualising each person with resultant compliance.

Slide 199



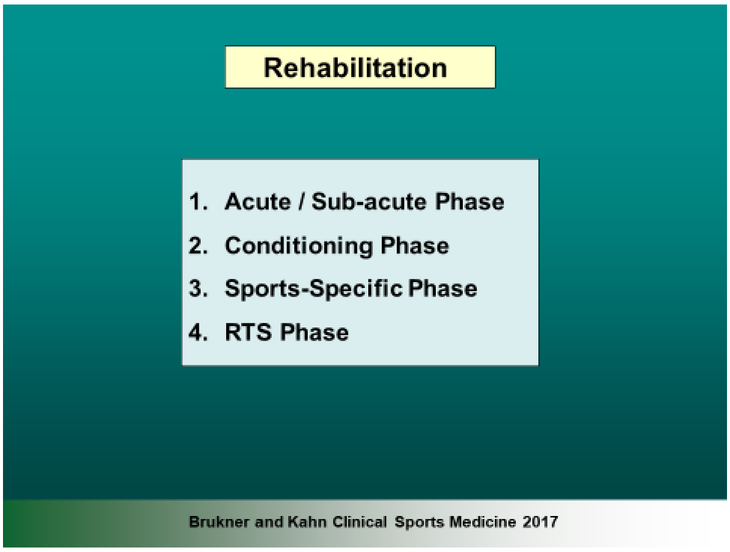
There are a number of different protocols regarding rehabilitation of the groin and hip which gives very definite progression based on a number of factors. A good example was shown in a case study dealing with a Premier League footballer whereby McAleer et al. (2015) highlighted an excellent nine-point plan for a rehabilitation protocol to manage recurrent "osteitis pubis / pubic bone stress" (Slide 199). They used non-time dependant clinical objective markers as guidelines for progression and functional measures normalised to body mass as prophylactic guidelines.

Slide 200

Kemp and Crossley (2016) shared their useful goals of treatment and resultant strategy to be followed for organising rehabilitation of a hip or groin injury (Slide 200).

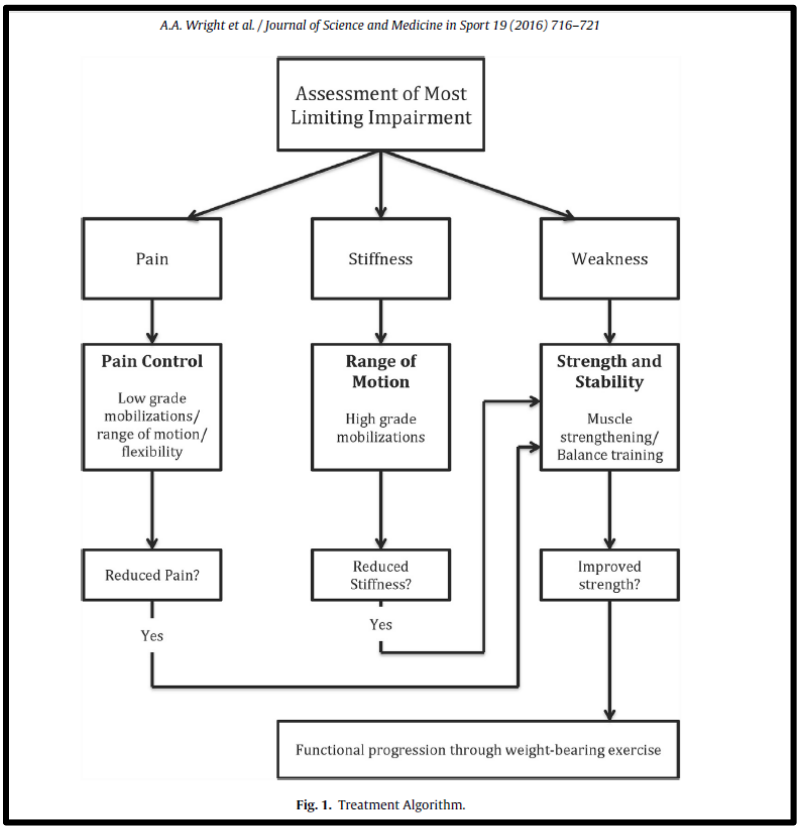
There is no specific protocol or "one size fits all" for rehabilitation of the hip and groin. The clinicians develop their own protocols and constantly analyse studies or presentations that demonstrate a particular protocol. Within my profession when I give presentations on this topic, I am constantly asked for an exact and specific protocol. I am passionate about relaying the message that each clinician has within their power the ability to individualise and provide a rehabilitation protocol without a "given recipe". Although there are some studies that demonstrate basic structures for progressive rehabilitation e.g. Slide 200, I devise a protocol based on each athlete's individual needs and their particular sport. I continue to be aware of the studies and their specific protocols on an ongoing basis in order to improve my approach e.g. Kemp et al. (2019). This thesis has been most useful for me to constantly analyse my own approach and evolve my management based on new studies, meaningful groin and hip conferences and communication with specialists in this field.

Slide 201



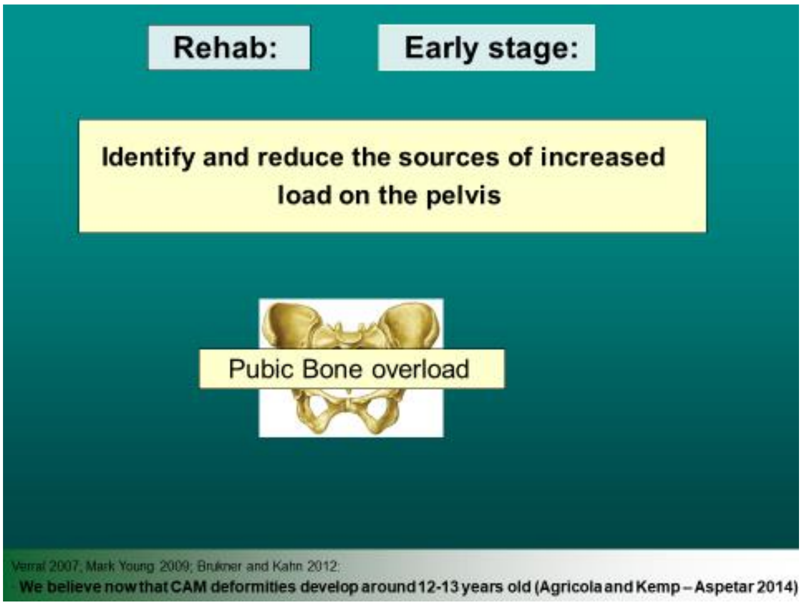
The different phases of rehabilitation need to be considered as in Slide 201 and then the criteria for progression to each phase, including return to training, return to playing and return to full performance. Matchotka et al. (2009) suggested that a duration of intervention of between 3.8 to 16 weeks may be required for exercise intervention to be effective. This is in stark contrast to routine practice, where there is often great pressure to speedily return an elite athlete to his/her sport. This, along with the financial pressure of professional sport can lead to shortened periods of intervention and a premature return to sport with possible negative consequences.

Slide 202



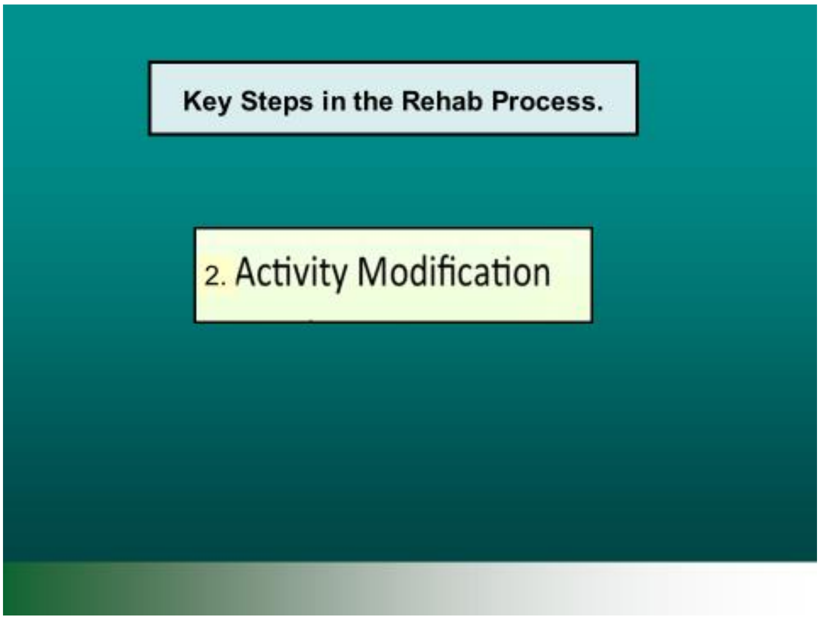
The early stage of rehabilitation should not be underestimated as one cannot progress without first managing these diverse factors e.g. inflammation. Further, one has to take all the factors into consideration from the early stage and throughout the different stages of rehabilitation (Slide 202).

Slide 203



When presented with any groin or hip problem, my first concern is to identify and reduce the sources of increased load on the pelvis (Slide 203). This may be by radiological imaging of the pubic area and assessing the training and match play of the athlete. Controlling the mechanical load is the cornerstone of rehabilitation, as well as optimising mechanical alignment, addressing muscle imbalances, observing movement patterns, assessing strength and range of motion and most importantly, making sure that the neuro motor control / proprioception is fully functional.

Slide 204



Thus activity modification is most important (Slide 204). It is not necessary to always totally exclude the athlete from his / her sport as this depends on the severity and specificity of the pathology. The exclusion from sports participation may be particularly important where there is an acute on chronic condition or where children or adolescents are involved.

The middle stage, advanced stage and criteria for return to sport may be structured on an individual basis, including recognition of relevant studies, clinical reasoning and experience. To this day, I still find it difficult to be precise or dogmatic regarding moving through the different phases of rehabilitation and continue to design and implement my own strategies by creating an algorithm which can be altered according to the needs of each individual athlete. This can be based around the 4 stages: Acute / Sub-acute Phase; Conditioning Phase; Sports-Specific Phase and Return to Sport Phase.

8d. Important Considerations for Rehabilitation

8d i. Biomechanics

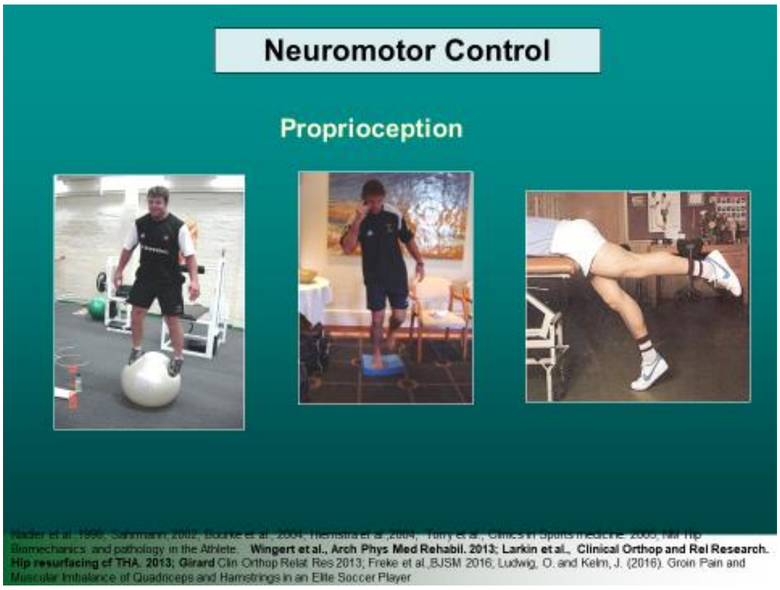
While this topic has been described extensively in Chapter 4 – Biomechanics, it is appropriate to re-iterate the importance of biomechanics with respect to rehabilitation.

When rehabilitating an athlete with groin related pain, optimal function and effective load transfer along the whole kinetic chain needs to be addressed. This would include analysis of the posture and pelvic tilt and the effect this has on the entire kinetic chain, the hip joint and walking / running patterns (Gebhart et al., 2014; Lewis et al., 2007, 2010; Lewis and Sahrmann, 2015; Ross et al., 2014). Also observation of the biomechanical implications if the pelvis is unstable or incorrectly aligned or the hip stabilisers are weak. This includes imbalance of Gluteal muscles and its effect on the pelvis, hip and entire kinetic chain (Barton et al., 2013; Cowan et al., 2009; Ferber et al., 2011; Ferber et al., 2015; Kendall et al., 2010; Kim, 2016; Mohammad et al., 2014; Sugimoto et al., 2014; Takacs and Hunt, 2012; Verrelst et al., 2014). Thus the clinician would target the lumbo-pelvic region and assess the possible compromised ability to maintain lumbo-pelvic position during limb movement tasks and note the importance of interpreting these movement patterns and the effect of the frontal plane kinematics on movement (Creaby et al., 2017). An example was shown by
Hislop et al. (2020) who demonstrated that walking improved after the addition of hip strengthening to quadriceps strengthening in people with knee osteoarthritis.
I have no doubt from my experience that working on these biomechanical factors has positive impact for the entire kinetic chain.
Further, men and women with hip-related groin pain display different lower limb biomechanics in both low and high impact tasks (King et al., 2019). The fatigue element also needs to be factored in when rehabilitating these athletes (Greig and McNaughton, 2014).

8d ii. Neuromotor Control

A recent study explained that there is high quality evidence to support the widespread use of neuromuscular training warm up programs in team and youth sport, with an expected significant impact of reducing the risk of musculoskeletal injury by over 35% (Emery and Pasanen, 2019). As has been described previously, neuromotor control and the correct transfer of load is a fundamental procedure for any rehabilitation protocol. Motor control training should target deficits in the neuromotor control of the lumbo-pelvic region, allowed improved dynamic trunk control (especially in youth) (Hides and Stanton, 2014; Lee and Powers, 2014; Myer et al., 2008).

Slide 205



Slide 205 demonstrates a number of different neuromotor control exercises e.g. the middle photo shows the importance of undertaking certain exercises such as one leg standing on a balance mat which has to be performed with specific daily triggers in order to be performed frequently and thus train the neuromotor control accordingly e.g. every time the phone rings. This was undertaken with all my players in elite rugby. Further, the picture on the right shows the value of sequence of movement by observing the order of movement of the gluteus maximus, hamstrings and the erector spinae muscles by extending the leg in this position. Defaults including erector spinae overworking due to weak gluteus maximus is frequently noted and can be used for rehabilitation and prevention management

Slide 206

Neuromotor control should be taught with proper muscle activation and recruitment patterns (Netoe al., 2019), as shown in Slide 206 (Ellsworth et al., 2014). I believe that these basic exercises should be undertaken as a mandatory procedure before applying individual strengthening exercises.

One should also take cognisance of neuromotor control during the earliest stage of rehabilitation / management i.e. pain and oedema control and any relevant physiotherapy management, as the neuromotor control will then function more effectively thereafter.

Slide 207

As I have said previously, I believe that I have made a difference in my professional management of patients over the past 28 years by using Proprioceptive Neuromuscular Facilitation (PNF) as a major tool for assessment, prevention and rehabilitation strategies. In particular, the flexion, adduction and external rotation in supine lying can demonstrate a number of weakness e.g. weakness in hip flexion and adduction in inner range (Slide 207). In the kicking action this is a required repetitive action and strengthening in this pattern of movement has been useful for functionality of my rugby players. I believe, through constant observation of this technique that the outcome is injury prevention. Although this is anecdotal, I appreciate sharing this technique with my colleagues (including Premier League) over the years and feel that they can implement this PNF technique and recognise the positive results.

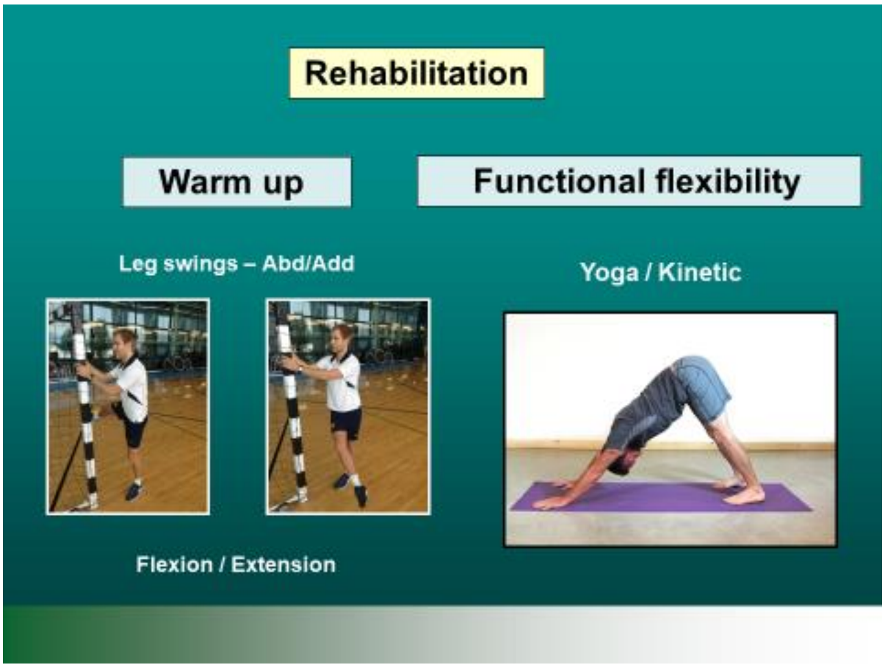
Ju and Yoo (2017) compared anterior Gluteus Medius fibre activation during general exercises and PNF exercises and ascertained that greater anterior Gluteus Medius fibre activation was observed during the PNF exercises compared with the general hip abductor strengthening exercises. PNF as a stretching technique will be discussed further in the following section. Further studies showing the value of PNF strategies, although not all directly related to the groin, include Akbulut and Agopyan, 2015; Cho and Gong, 2017; Gong, W. 2015; Onoda et al., 2015 and Szafraniec et al., 2018.

Regarding the value of neuromotor control, I share an anecdotal observation of one of my case studies involving a 46-year old female, who was an active hiker and suffered from chronic Gluteus Medius tendinopathy. Having analysed all the biomechanical abnormalities / adaptations, I devised a method to reduce pain by a gentle feedback of her neuro-motor system. She thus was told to commence a simple exercise i.e. a gentle double leg squat (not too low) 3 – 5 times after sustained sitting, or at any time when there was pain or even discomfort. She had a great deal of pain after sitting in front of the computer or sitting for a long time in a car. This simple squat exercise would reduce the pain and she could move on. Individual strengthening exercises for hip abduction (such as the clam exercise) caused strong pain. She even went up some steep mountains one weekend with her pain starting with 6/10. However, every time she felt pain, she stopped and did the squats – gently and slowly with strong focus. This enabled her to complete the mountain hike with the pain alternating between 4 and 6 out of 10. The pain eventually subsided over a few weeks and she could then do the individual abductor exercises. She now has no problem and continues to do the minimal squat if sitting for extended period or with any strenuous activity. My hypothesis is that the neural feedback with no pain after performing the minimal squat caused the feedforward to function correctly and not "shut down" / tighten the muscles. This case study is anecdotal and I feel it would be of great value if a study could be undertaken with this outcome. More studies are being developed to show the value of the neuromotor system for rehabilitation. Meanwhile, I believe that as a clinician, I have the power to develop new inventive strategies and note the outcome.

8e. Components of a Rehab Programme

8e i. Warm Up and Flexibility

Slide 208



Warming up and functional flexibility prior to training or matches is a pre-requisite (Slide 208) and I have found it interesting to see the changes over the past 20 years. In particular, the fact that static stretches should not be performed prior to exercise, as functional flexibility is the more beneficial strategy. This was a highlighted for me in 1998 when I travelled with the South African Ladies Hockey to the World Championships and was surprised to note the teams such as China and Japan, who did dynamic stretching, as opposed to New Zealand, Australia, UK and South Africa's static stretching protocol. China and Japan (and others doing this strategy) scored more goals in the first quarter compared to their opposition. Subsequently, all major countries have realised the value of functional warm up strategies and more studies are being produced to examine this.

There has been much debate in recent years over different stretching protocols and its effect on performance (Behm et al., 2016; Blazevich et al., 2018; Kallerud and Gleeson, 2013; McHugh and Cosgrave, 2010; Peck et al., 2014). This is particularly regarding static or dynamic stretching and timing thereof. Although not specific to the groin area, the principles remain the same and one should note the ongoing discussions. Dynamic stretching has been confirmed to be a suitable alternative to static stretching as part of a warm-up, particularly prior to explosive or high-speed activities (Opplert and Babault, 2017; Vazini and Parnow, 2017 and Zhou et al., 2019).

Lempke et al. (2017) discussed the effectiveness of PNF vs. static stretching on increasing hip flexion range of motion. The reviewed evidence suggested that PNF stretching is equivalent to static stretching in regard to improving hip-flexion ROM and more research is required. However, static stretching is known to possibly compromise performance by reducing power and thus one has to be wary of the timing of static stretching (Loughran et al., 2017). From my experience, there is definitely a place and time for both stretching techniques such as PNF (and dynamic) stretching prior to training or matches and static stretching at other times when not participating in sports activities (for more plastic deformation).

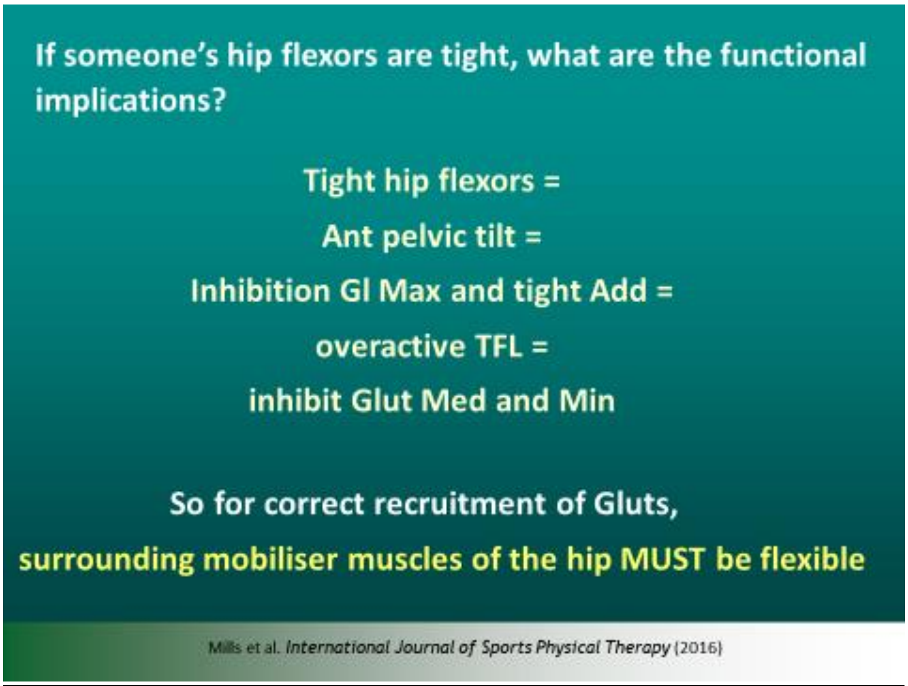
Slide 209

Further, from my practical experience, the PNF technique (contract /relax) was of immense benefit for the rugby players (and other elite athletes) when they presented with tight Ilio-Psoas, Rectus Femoris or Abductors muscles (Slide 209). This was most common with the rugby forwards. A short session of contract-relax in supine lying position as above, would immediately relax / lengthen the muscles prior to training or matches. They would then proceed to warm up with dynamic stretching and functional exercises. Anecdotally, I believe that this protocol was of benefit for prevention of injuries and also enhanced performance. To date there are very few studies regarding this strategy (Szafraniec et al., 2018 - hip joint muscles; Younis et al., 2018 – hip flexors; Burgess et al., 2019 - hamstrings). It would be helpful if more research would be undertaken to support the use of PNF for prevention and rehabilitation. Reflecting on my career and these anecdotal strategies, I am disappointed that I did not organise research regarding the positive outcomes accordingly. This could be an area for future professional development.

However, in spite of ongoing studies and discussions regarding the type of flexibility protocol that best benefits the athlete, it is important that once tight muscles have been identified, the athlete should work on flexibility on a daily basis, bearing in mind elastic deformation and structural deformation and be aware of its relevance to the specific sport and the timing of the stretching session relative to the sports performance.

In my experience the different stretching protocols such as static, dynamic and PNF protocols are all effective when used at the right time as explained above.

Slide 210



The implications of tight muscles around the hip / groin and the resultant mal-adaptations / impairments as shown in Slide 210 require analysis. Mills et al. (2016) found that female soccer players with hip flexor muscle tightness exhibited less Gluteus Maximus activation and lower Gluteus Maximus: Biceps Femoris activation, while producing similar hip and knee extension moments.

Gore et al. (2018) examined a lateral hopping action in male participants, whereby the author's primary aim was to determine whether Athletic Groin Pain affected vertical and joint stiffness and whether successful rehabilitation would be associated with a change in stiffness. The outcome demonstrated that ankle plantar flexion, knee extension, hip abduction, and whole-body vertical stiffness was affected by Athletic Groin Pain and with the exception of hip abductor stiffness, did not improve following clearance to return to play. They suggested that it would be of benefit if future research could prospectively track Athletic Groin Pain patients following return to play to determine if an intervention with a greater focus on increasing whole body, knee, and ankle stiffness improves the efficacy of Athletic Groin Pain rehabilitation. Thus assessing and managing stiffness of the entire lower extremity is an important component of rehabilitation of any groin or hip problem.

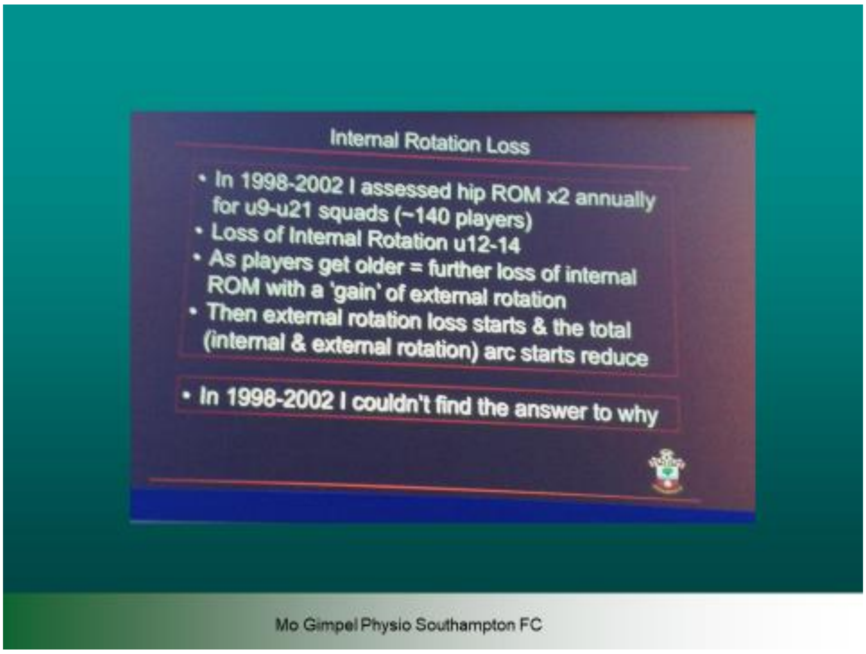
Slide 211

Although there is a paucity of studies to show the effectiveness of yoga when managing flexibility around the pelvic girdle/hips, recently Rathore et al. (2017) described specific yoga exercises as they relate to core muscles activation (Slide 211). Anecdotally, I have seen the benefits of these yoga movements. In my time with the Super 14 rugby players (2000-2006), I introduced a modified "Sun Salutations" yoga movement which became an integral part of the training and matches. This practice was adopted from a Dutch Hockey coach with whom I worked in the 1990s when I was with the South African Ladies hockey team. There appeared to be many benefits to using this yoga movement for the Hockey players, including improving kinetic flexibility, as well as strengthening muscles in different ranges of movement. I have subsequently used it in all my sports with relevant adaptations, and the observed benefits have resulted in the continued used of this technique. Clinically, I have also used these yoga movements with my hip and groin patients. However, all yoga should be performed with caution, good instruction and observed practice as, if performed incorrectly, it may cause damage. Good prior instruction for the clinician such as communication with the relevant instructor or attendance at a pertinent yoga class is advantageous, as proven by the men's Dutch hockey coach who taught me this technique.

8f. Caution: Managing ROM limitations

When discussing flexibility, clinicians analyse joint range of motion related to the adjoining muscles, as well as the joint itself. As stated previously (Chapter 5 – Tests), clinicians are taught to take any hip range of motion deficit to be a marker for potential hip problems and are advised to correct this in their exercise regime. Plus, clinicians are aware that patients with hip morphologies and a labral tear tend to exhibit reduced hip range of motion for flexion, internal rotation, and/ or adduction and may be the cause of groin and hip problems. A number of studies discuss the importance of hip range of motion and the effect any limitation may have on groin and hip areas (Ibrahim et al., 2007; Murphy et al., 2017; Reiman et al. 2013; Tak et al., 2016; Tak et al., 2017; Tak et al., 2018). This causes a dilemma for clinicians managing this groin/hip pain, as one is not sure if one should increase the ROM or leave it, as it may be different limited due to an adaptive change for a specific sport. This key point once again highlights the fact that clinicians are required to intensely investigate and comprehend the nuances of hip movement in a particular sport or position within the sport. I have found this to be most positive, albeit time consuming to explore movements in the field of sport. To me that is an excellent and informative way to learn and consequentially manage my sports injuries in all the different sports which have such variability. This gives the clinician specific knowledge, credibility from the athletes and an ongoing more comprehensive and successful management.

Slide 212



It is pertinent to take cognisance of the presentation by Mo Gimpel the Physiotherapist for Southampton football club, whereby he discussed this hip range of motion dilemma (Warwick Hip Conference. 2016) and the possible implications which are still not definitive (Slide 212). He also queried whether and how much one should increase this range of motion as it may be an adaptive change, as discussed previously. Certain sports, gender and even ethnicities have different hip range of motion (Cheatham et al., 2017; Han et al. 2019; Kolo et al. 2013; Mosler et al., 2016; Mosler et al., 2017; Steinberg et al., 2016). When rehabilitating an athlete, the clinician may have a possible incorrect assumption that the hip requires mobilisation in order to increase the hip range of motion and reduce the potential hip pathological change. Once again knowledge of the specifics of the sport and its effect of hip mobility is critical for correct management.

Thus one has to be cautious when assuming that an athlete with decreased hip range of motion automatically requires intervention to increase the range of motion. It would be of benefit if more studies were undertaken to give normative data in each sporting situation. Meanwhile, the clinician should take cognisance of all available factors and individualise accordingly e.g. relate the hip joint movement to that required in a specific sport. If there is no guideline, I personally would gently mobilise the hip joint and see if there was any outcome regarding any pain symptoms.

8g. Functional Exercises versus Individual Exercises

8g i. Background

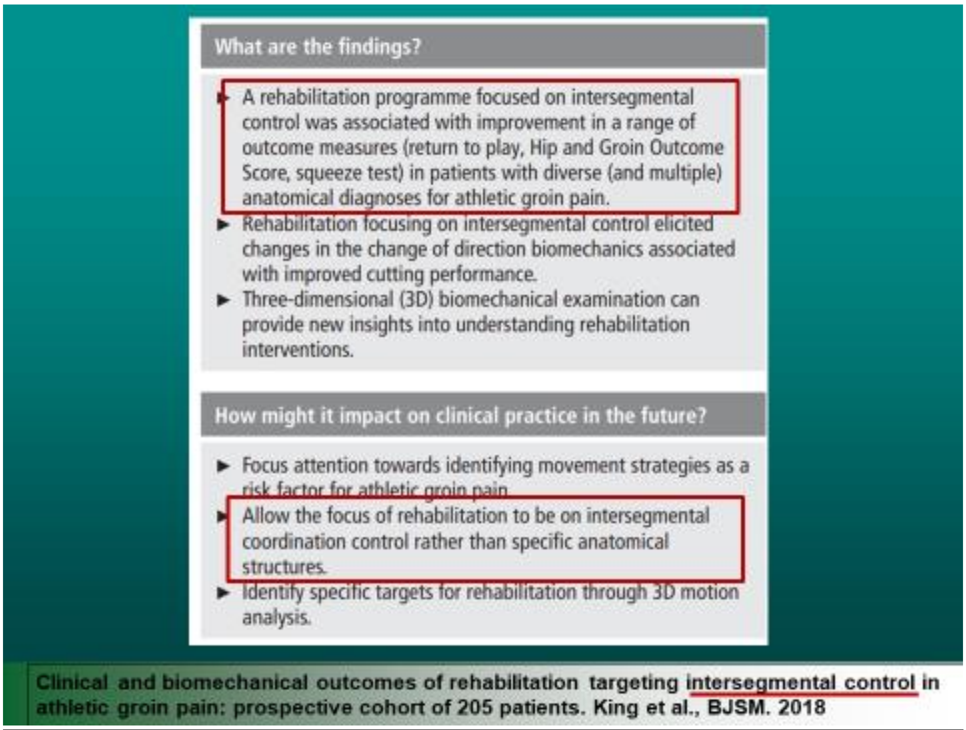
Whether to start with isolated exercises or functional exercises is not clear from the literature. Retchford et al. (2013) proposed interventions aimed at restoring isolated neuromuscular function of the primary hip stabilisers. This should be considered when treating people with passive hip instability due to hip pain and dysfunction prior to commencing global muscle rehabilitation or specific muscles strengthening.

At the Doha Conference, Franklyn-Miller (Doha, Qatar, 2014) strongly advocated functional exercises as the main rehabilitation protocol and not isolated strengthening exercises and/or single joint exercises. I would concur that getting functional movement e.g. dissociating pelvis and lower limb / lumbar spine, would be most important before doing individual strengthening exercises. That is not sacrosanct and the use of functional /specific exercises should be considered for each individual patient. Specific exercises are for strengthening the muscle and functional exercises brings in the neuro-motor control i.e. stimulates increases in muscle recruitment appropriate for the task.

At a conference presentation, Grimaldi (2015) specified that the clinician should consider joint loading during exercise prescription and at the same time modify or minimise negative loads. Exercise prescription is not all about strength. One should ensure the patient has appropriate low load muscle recruitment strategies first and then graduate load considering muscle balance and efficiency, appropriate joint ranges and alignment control. Following this strategy, I believe that undertaking functional exercises first, has had good outcome. Thus my absolute zeal to share this positive knowledge with all of my colleagues.

8g ii. Functional exercises

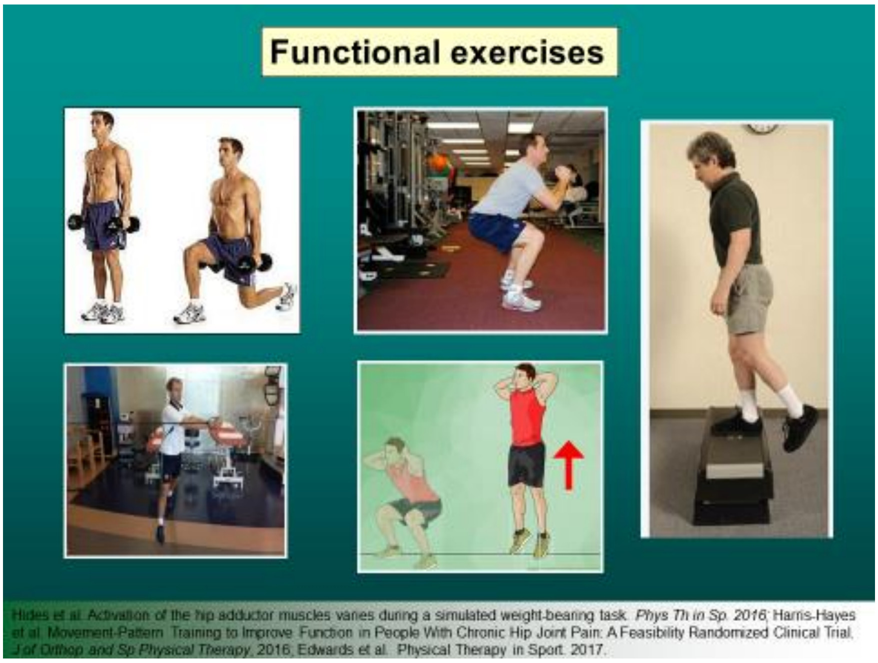
Slide 213



An excellent example of functional exercises, was shown by King et al. (2018) (Slide 213). They found an association of improvement in a range of outcome measures (return to play, hip and groin outcome score and squeeze test) in patients with diverse (and multiple) anatomical diagnoses for adductor-related groin pain with the use of a rehabilitation programme focused on intersegmental control. They deemed this to be far more useful then basing the rehabilitation on specific anatomical structures. From my professional experience, I totally concur with that protocol and have had similar outcomes.

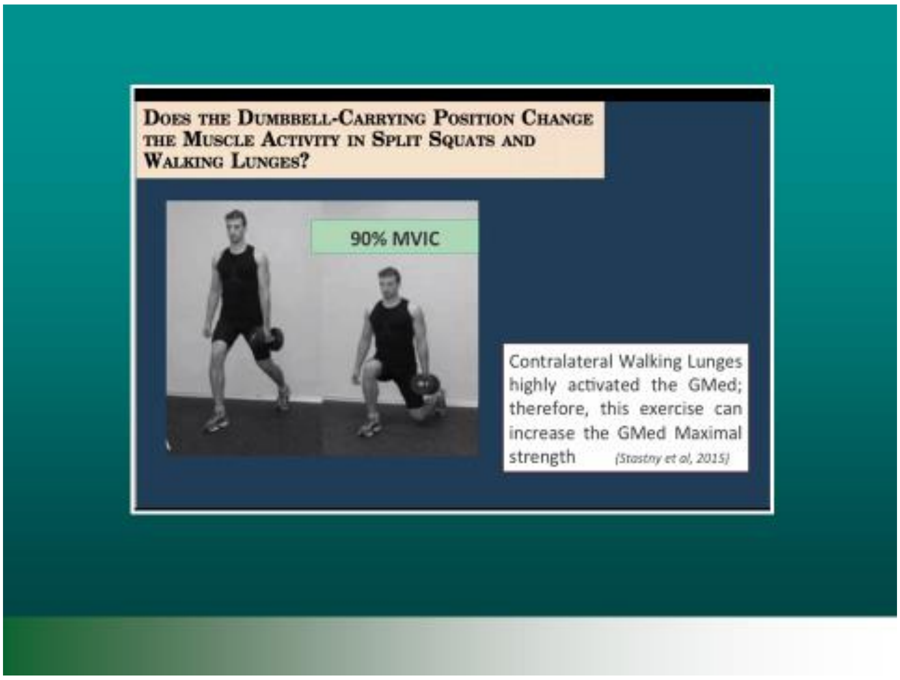
Training dissociation of the pelvic area from the upper body is successful for efficient movement of the entire kinetic chain, as well as preventing further groin /hip problems (as well as low back pain). This idea was reaffirmed by the physiotherapist Steve Wright (Southampton Football Club).

Slide 214



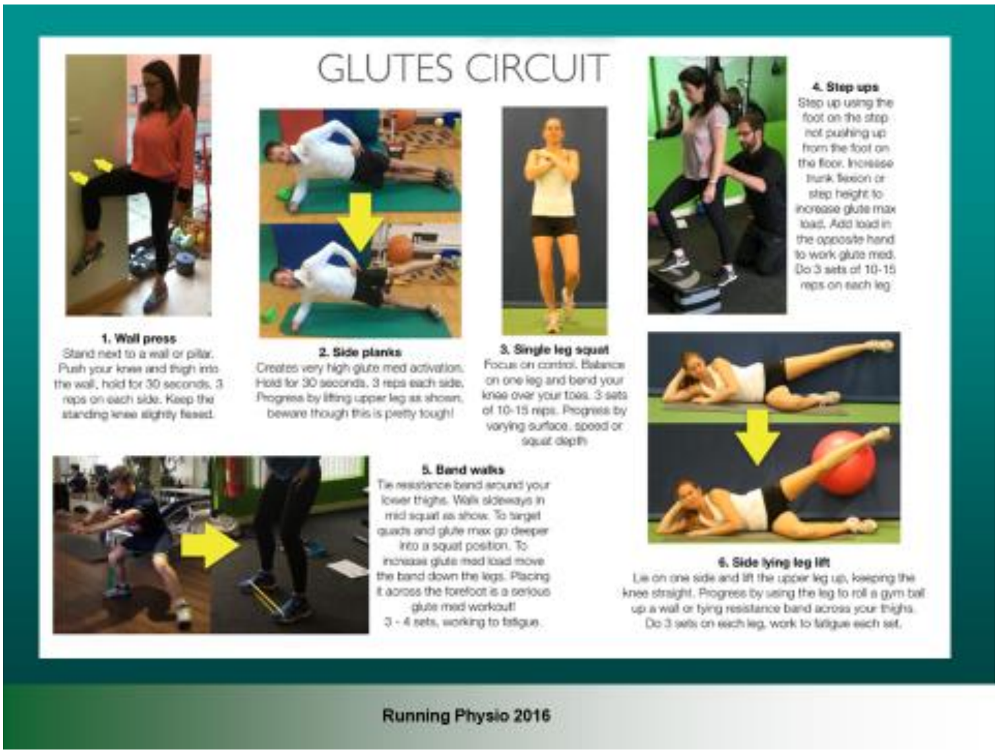
A variety of functional exercise are shown in Slide 214 and demonstrate the importance of involving the entire kinetic chain, which is of great value, particularly as it incorporates the neuromotor system. The timing of these exercises and the progression should be based on clinical experience with sound clinical reasoning, bearing in mind each individual and their specific requirements and goals.

Slide 215



More studies analyse the specifics of different functional exercises (Dello Iacono et al., 2017; Stastny et al., 2015) (Slide 215). Of note is that the single-leg squat generated relatively high activity levels in all 3 Gluteus Medius segments (Moore et al., 2019).

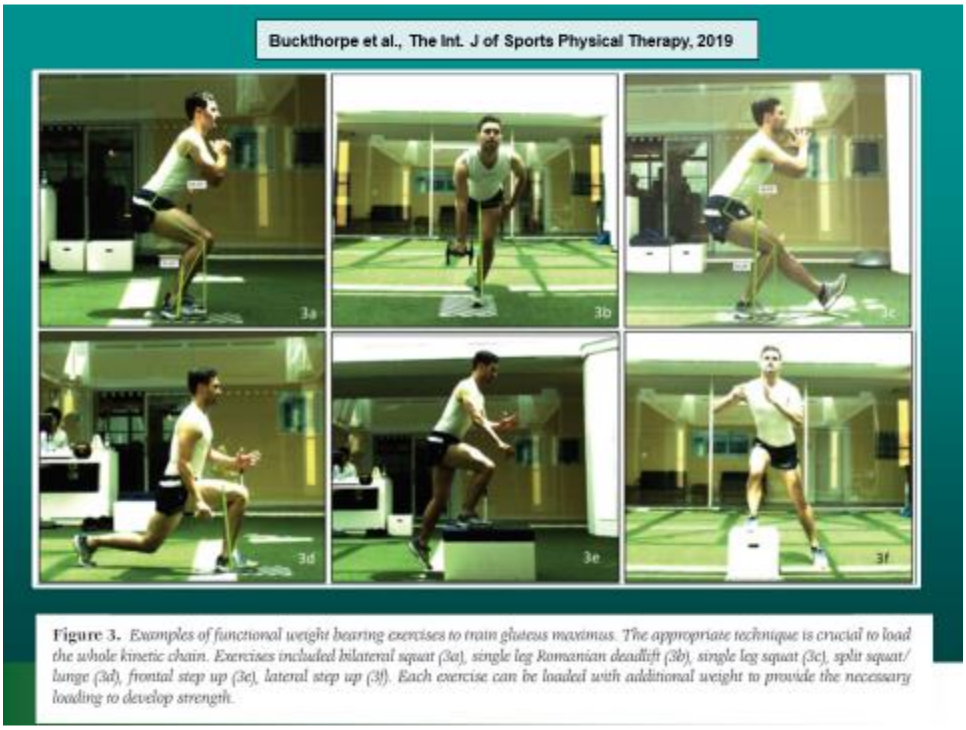
Slide 216



From a practical point of view, Slide 216 shows the value of a Gluteal circuit incorporating all the different demands on the different sections of the Gluteal muscles, which was based on the study by Reiman et al. (2012). A circuit should be individualised to strengthen specific muscles whilst incorporating them in a functional manner and thus engaging the relevant kinetic chain.

Regarding Gluteus Maximus, an informative clinical commentary demonstrates treatment approaches based on utilizing a holistic approach (Buckthorpe et al., 2019). This includes releasing and lengthening the antagonists, realigning the pelvis, developing lumbo-pelvic stability, strengthening Gluteus Maximus and integration it into basic motor patterns, as well as then optimizing its function through restoring explosive neuromuscular and sporting performance. Thus although there are specific exercises for this muscle, they declared that movement re-integration and patterning programme was needed prior to progressing to a strength, power and sports based exercise program.

Slide 217



Slide 217 gives examples of functional weight bearing exercises with high level Gluteus Maximus activation. The step-up exercise and its variations present the highest levels of Gluteus Maximus activation followed by several loaded exercises with variations, such as deadlifts, hip thrusts, lunges, and squats (Buckthorpe et al., 2019).

Slide 218

Further, it important to include trunk rotation when rehabilitating groin and hip injuries (Slide 218).

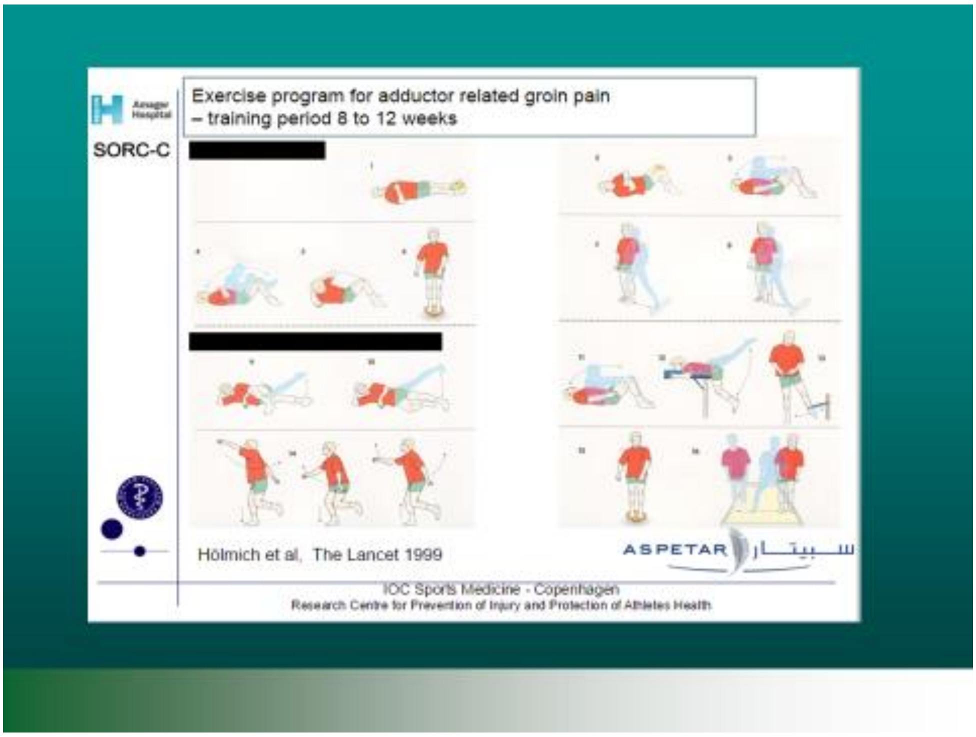
8h. Specific exercises and implications

8h i. Background

Although I find great value in functional exercises, there is no doubt that a weak muscle associated with the hip or groin requires strengthening. Specific exercises targeting these precise weaknesses should be considered if assessment identifies the relevant weakness. There are studies which have identified a number of weak hip muscles in patients with hip and groin injuries e.g**.** Harris-Hayes et al. (2014); Hatton et al. (2014) and Mastenbrook et al. (2017).

Ongoing studies identify the different activation of a muscle with a certain exercise, which can be most helpful for rehabilitation. Across different exercises, variation exists based on the exercise type, whether it is a weight bearing or non-weight bearing activity, whether it is a unilateral or bilateral exercise, the underlying surface on which the exercise is performed, and the relative trunk and/or hip position. Variability across studies investigating the same (or similar) exercises also exists. Ebert et al. (2016) suggested that specific exercise prescription, as well as the aforementioned factors, in interpreting and then applying the results in a clinical environment is required. In particular, they felt that the clinician needs to accommodate individual patient findings, as well as their activity history, pathological and pathophysiological considerations and any adjunct conditions. Thus before undertaking specific rehabilitation exercises, it is useful for the clinician to take cognisance of the implications of a specific exercise on each muscle or section thereof.

Slide 219



The exercises recommended by Holmich et al. (1999) for Long Standing Athletic Groin Pain are still currently in use with some modification to the programme as shown at the Aspetar Conference (2014) (Slide 219). Their research demonstrated that Adductor-related groin pain could be successfully treated with active training even in the presence of morphological changes to the hip joint, with results lasting 8-12 years (Holmich et al., 2015). Yousefzadeh et al. (2018) agreed that exercise therapy according to the Holmich programme may be an effective treatment for Long Standing Athletic Groin Pain. However, they ascertained that more emphasis should be paid to the hip adductor muscles' eccentric strength. From my experience, this has definitely been an oversight and neglected for many years within elite sports.

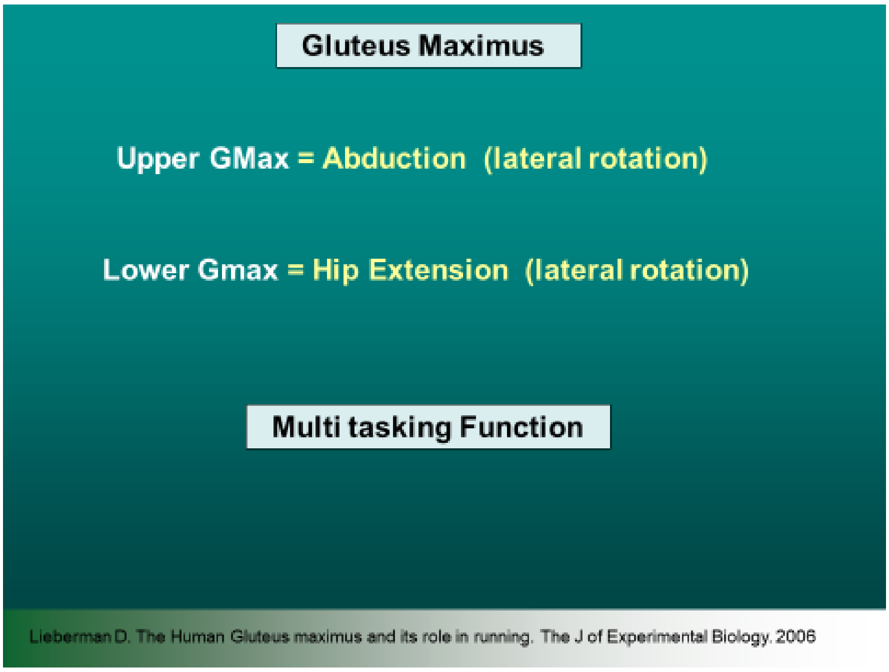
8h ii. Specific exercises and muscles involved.

A number of studies have evaluated the Gluteus Maximus and Gluteus Medius muscles during certain exercises. This is helpful when analysing the true value of each exercise on a specific muscle which requires strengthening.

- **Gluteus Maximus**

The Gluteus Maximus muscle is the largest and most powerful in the human body. It plays an important role in optimal functioning of the human movement system as well as athletic performance. It is however, prone to inhibition and weakness which contributes to chronic pain, injury and athletic under-performance (Buckthorpe et al., 2019).

Slide 220



The multi-function tasks of the Gluteus Maximus, (as shown in Chapter 3b iii - Anatomy), are often not taken into account when rehabilitating an athlete (Slide 220). Lieberman et al. (2006) explain most succinctly the role of Gluteus Maximus. Humans today use their Gluteus Maximus far less than in the past. It is mainly a climbing muscle and is used in sprinting and not in walking. AS has been mentioned previously, when rehabilitating an athlete who requires sprinting activities, one also has to address the athlete's activities of daily living as many athletes spend most of the day sitting in front of a computer (which will lengthen and weaken the Gluteus Maximus). They then engage in sprinting sports which requires the Gluteus Maximus to contract maximally in a shortened position.

This factor was highlighted for me when I travelled with the South African team to the Commonwealth Games (1994). Our top South African sprinters had noticeably small Gluteus Maximus muscles compared with their counterparts e.g. Usain Bolt and coincidentally did not perform as well. In the past I have underestimated the relevance of this muscle and have rectified this deficit of my management accordingly by very specific strengthening of the Gluteus Maximus relevant to the sport undertaken. I thus feel strongly about sharing this “new” positive information in my presentations.

Slide 221

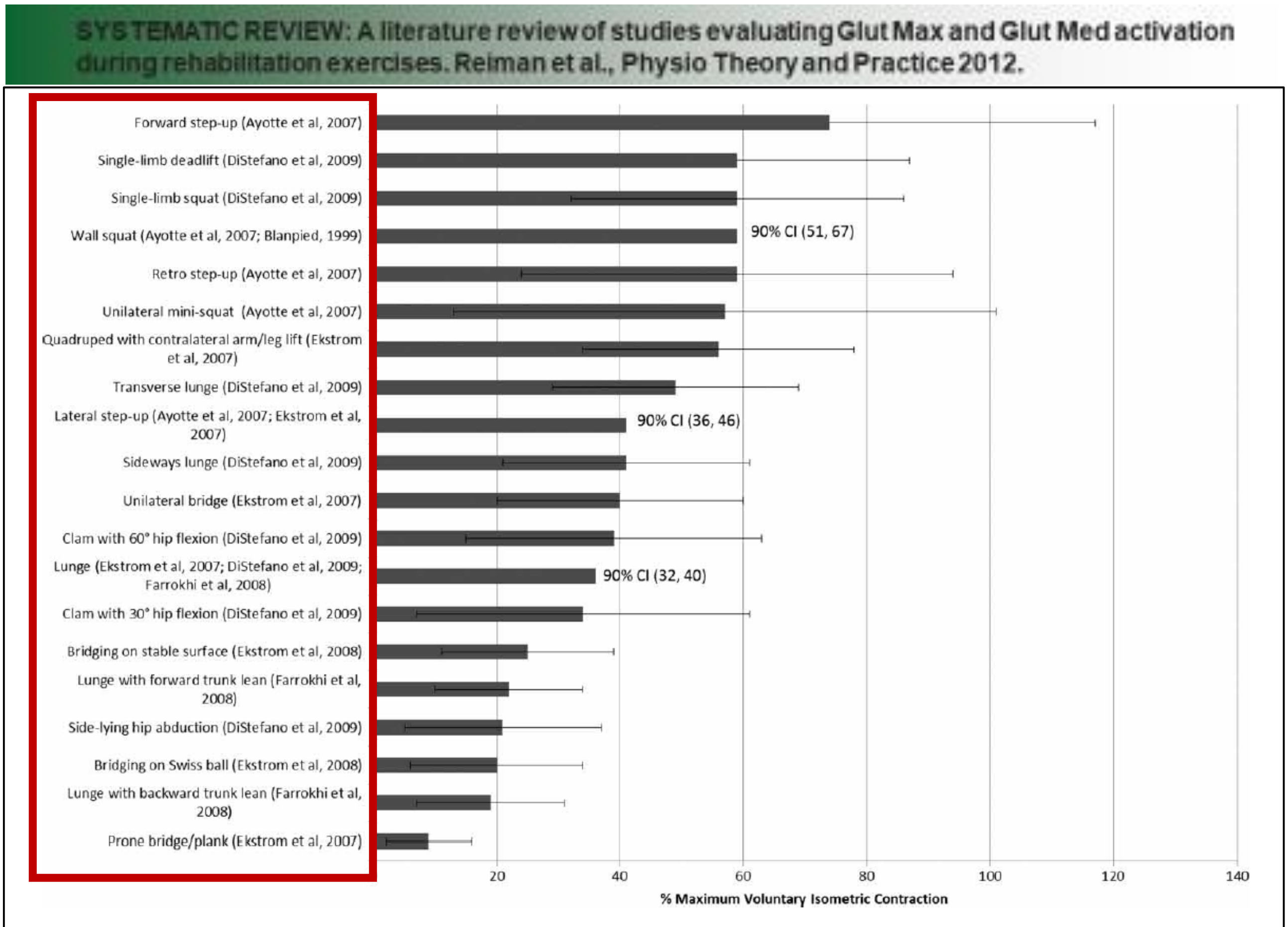
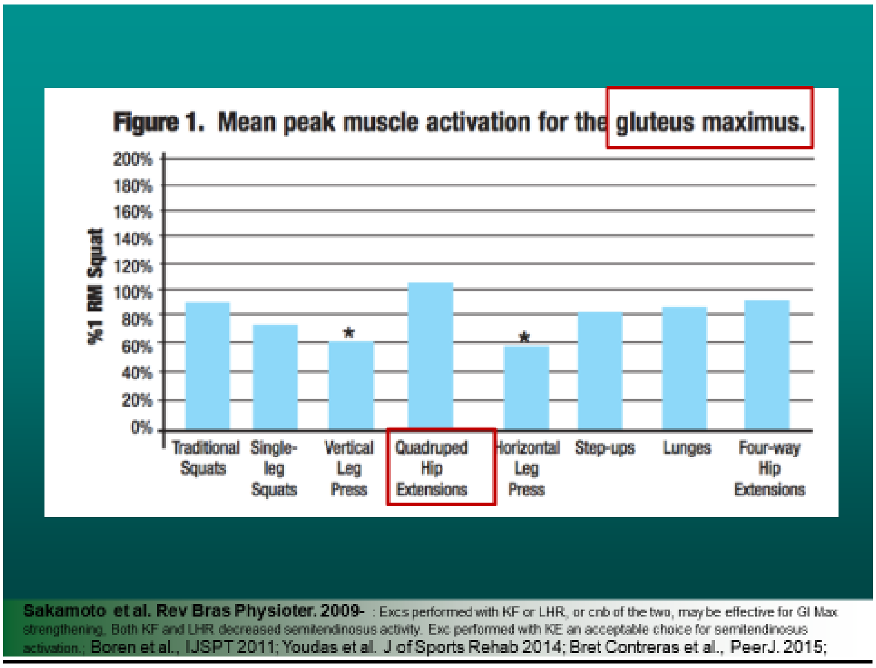


FIGURE 1 Gluteus maximus percent maximum voluntary isometric contraction ranking of exercises.

Slide 221 shows why it is of value to analyse studies which explain different exercises and their effect on Gluteus Maximus. According to Reiman et al. (2012), the best exercise for Gluteus Maximus is the forward step-up.

Slide 222



Contrary to Reiman et al. (2012), Sakamoto et al. (2009) showed the exercise that engaged the Gluteus Maximus most of all was the quadruped hip extension (Slide 222). This was investigated further by Kang et al. (2016) who showed the discrepancy regarding different hip abduction angles during bridging exercise. Bridging with isometric hip abduction using a theraband is also an effective method to facilitate Gluteus Maximus muscle activity (Choi et al. 2015).

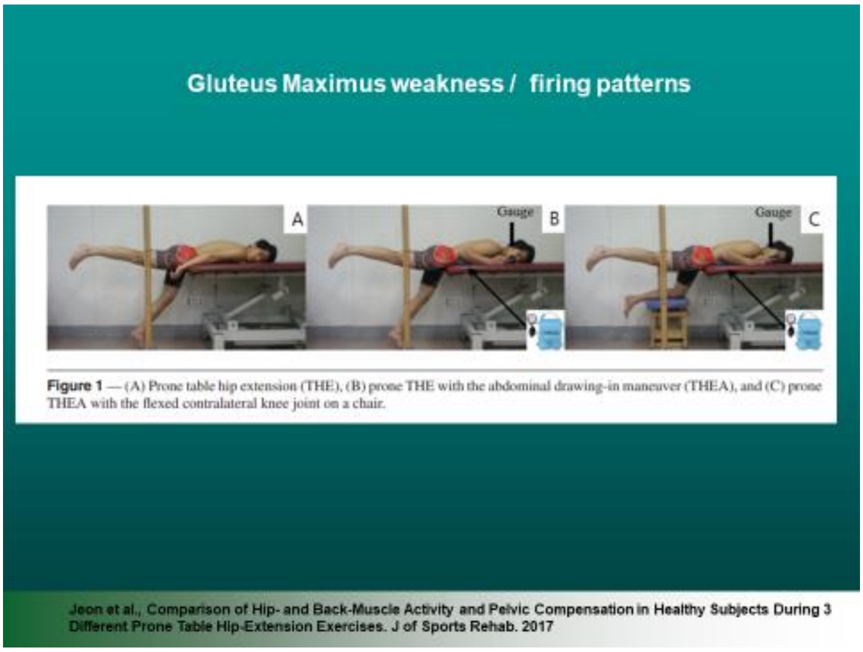
When organising a rehabilitation protocol, the clinician should also take into consideration the fact that co-contraction of the Gluteus Maximus with the Psoas Major contributes to lumbo-sacral stabilisation, as does its connection to the thoraco-lumbar fascia which assists in supplying rotational stability to the lumbar spine (Andersson et al., 1995).

Another aspect when discussing gluteal muscles, is that most hamstring strain research has focused on the hamstring muscles themselves. A neglected aspect of rehabilitation is the fact that the hamstrings have two synergist muscles (the Gluteus Maximus and the Adductor Magnus). Weakness or low activation of these two synergist muscles during the sprinting movement could theoretically lead to an increased risk of a hamstring strain, as the hamstrings have to contribute more force as a result. This was examined by Schuermans et al. (2017), who found that amateur soccer athletes who displayed low Gluteus Maximus activation during the flight phase of accelerating sprinting were more likely to incur a hamstring strain in the 1.5 seasons after baseline testing. Previously, Wagner et al. (2010) explained how a program of

Gluteus Maximus strengthening and neuromuscular training eliminated exercise-associated cramping of the hamstrings in a triathlete. Thus recognising synergistic relationships are relevant for the rehabilitation of hip and groin pain.

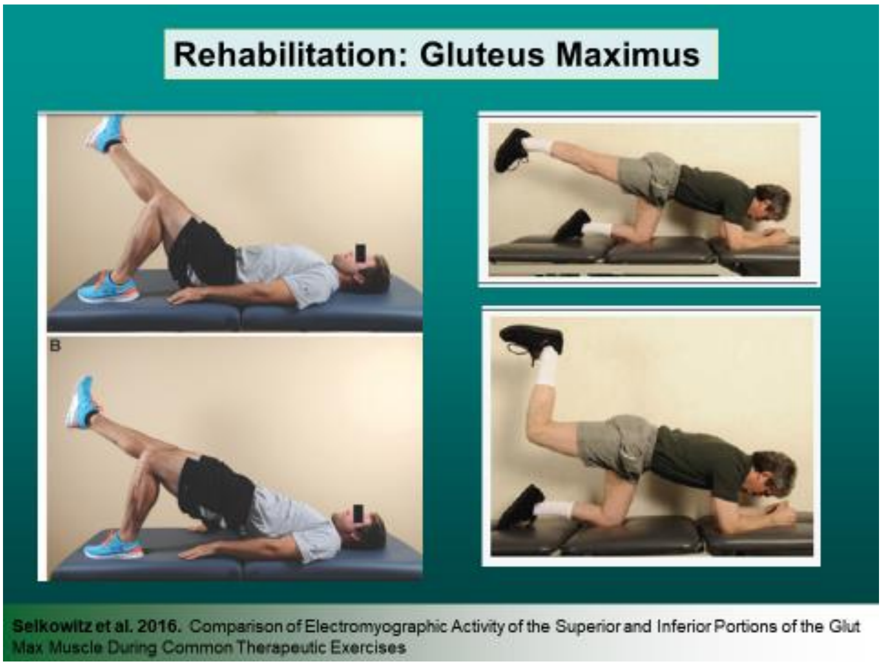
In people with low back pain, hip extension is initiated by the hamstrings and contralateral erector spinae instead of the Gluteus Maximus (Arab et al., 2011). Thus rehabilitation needs to focus on re-activating the Gluteus Maximus muscles and strengthening it accordingly**.**

<u>Slide 223</u>



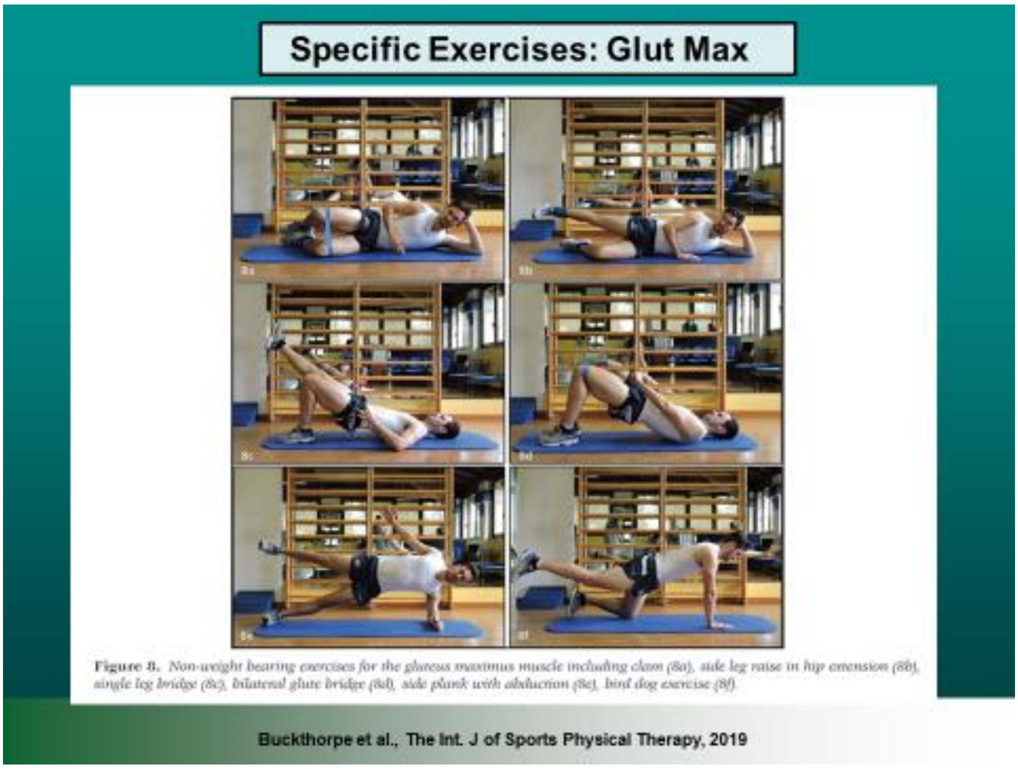
Studies showing Gluteus Maximus strengthening exercises in different prone lying positions include Jeon et al. (2016); Lewis and Sahrmann, (2009); Oh et al. (2007) and Sakamoto et al. (2009). Jeon et al. (2016), compared three different prone lying exercises as shown in Slide 223. The result was that the chair support under the knee exercise was the most effective for strengthening the Gluteus Maximus without over-activity of the Erector Spinae, Biceps Femoris, and Semitendinosus muscles and any lumbo-pelvic compensation. Specifically, during clinical evaluation of a patient with hip pain or hip extensor muscle dysfunction, it would be useful to monitor the patient for abnormalities in muscle activation and sequence of movement. Furthermore, the gender of the patient, the muscles being monitored, the method of performing prone hip extension and the motion of the knee requires consideration.

Slide 224



Knowledge of how the different portions of the Gluteus Maximus are activated during therapeutic exercise may lead to more specific exercise prescription that incorporate elements of hip abduction and/or external rotation (Selkowitz et al. (2016) (Slide 224). I use both of these exercises with the bridge exercise being my preferred one, particularly with a ball between the knees to activate the Adductor muscles.

Slide 225



A few specific Gluteus Maximus exercises that I have utilised with positive outcome are demonstrated on Slide 225

- **Gluteus Medius and Gluteus Minimus**

Despite the importance of the Gluteus Maximus dominant exercises (squats, lunges, bridging and deadlifts) in improving hip extensor strength, a focus on one particular plane may result in neglect of the lateral gluteal muscles (Gluteus Medius and Minimus).

Slide 224

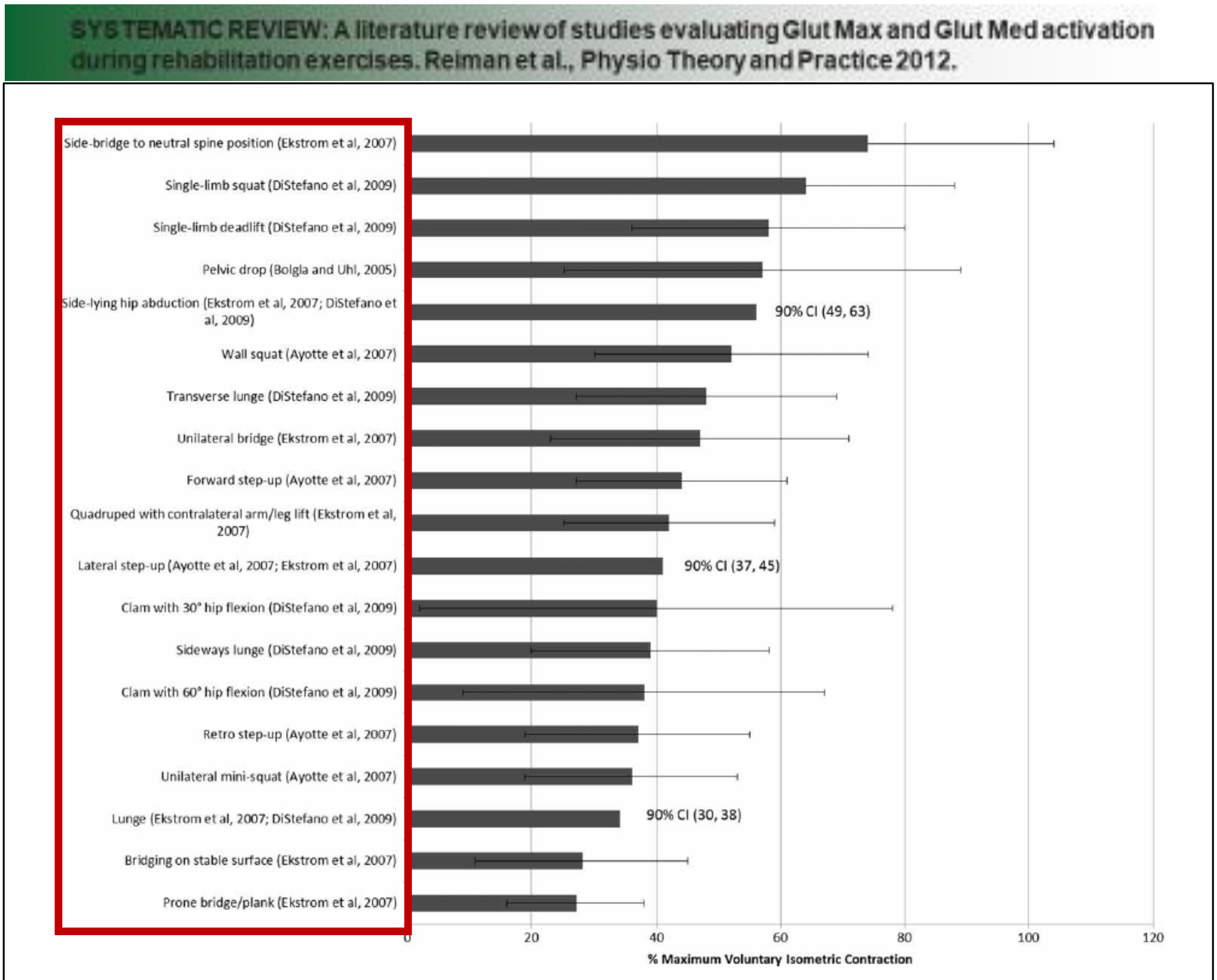


FIGURE 2 Gluteus medius percent maximum voluntary isometric contraction ranking of exercises.

According to Reiman et al. (2012), the best exercise for Gluteus Medius is the side bridge to neutral spine position (Slide 224).

Slide 225

The weakness of the Gluteus Medius and Minimus and the consequential implications has been described by Fetters et al. (2019) (Slide 225). Weakness may have an impact, not only on the pelvis and hip area, but may also cause knee or lower back pathologies. The value of recognition of the different permutations of Gluteus Medius has been extensively covered in Chapter 3, Part 2 – Anatomy and this knowledge is of great benefit when devising a rehabilitation protocol.

Allison et al. (2016) studied the effect of hip abductor strength in individuals with gluteal tendinopathy. Although the exact “hip abduction” muscles were not emphasised (except for a brief comment about the atrophy of the Gluteus Medius and Gluteus Minimus contributing to hip abductor weakness in Gluteal Tendinopathy), the results showed that people with unilateral Gluteal Tendinopathy demonstrate significant weakness of the hip abductor muscles bilaterally when compared with healthy controls. Although it is not clear whether hip weakness precedes Gluteal Tendinopathy or is a consequence of the condition, the findings provide a basis to consider hip abductor muscle weakness in the treatment plan for management of Gluteal Tendinopathy. Individuals with Gluteal Tendinopathy exhibited modified muscle activation patterns of the hip abductor muscles during walking, with potential relevance for gluteal tendon loading. The weakness of these muscles may result in excessive hip adduction during dynamic loading, thereby contributing to the development and exacerbation of gluteal tendinopathy.

The value of strengthening the Gluteus Medius and Minimus muscles in a rehabilitation protocol is highlighted in a number of studies, particularly in athletes with Gluteal Tendinopathy e.g. Allison et al. (2014); Allison et al. (2016); Grimaldi et al. (2015).

As the Gluteus Maximus is a primary external rotator of the femur with the leg in neutral position, hip abduction with extension reduces the Gluteus Maximus role as an external rotator and thus emphasizes the posterior fibres of the Gluteus Medius. Though currently rarely targeted in a rehabilitation protocol, the posterior fibres of the Gluteus Medius are unique and contribute to overall performance of the muscle. Strengthening of the Gluteus Medius improves lower extremity power, reduces future risk in the uninjured athlete, and improves rehabilitation in the injured athlete (Grimaldi 2015).

Table 16: Specific Gluteus Medius Exercises

Author	Aim	Outcome
Bolgla and Uhl, (2005)	EMG analysis of hip rehabilitation exercises in a group of **healthy subjects**	**WB exercises and NWB side-lying hip abduction exercise resulted in greater muscle activation** because of the greater external torque applied to the hip abductor musculature. Although the **NWB standing hip abduction** exercises required the least activation, they may benefit patients who cannot safely perform the WB or side-lying hip abduction exercises.
Thorborg et al. (2010)	Effect of a six weeks programme of side-lying hip abduction training, with and without external loading, on hip abduction strength in healthy subjects.	**Side-lying hip abduction training, using only the weight of the leg as loading can be recommended** as an efficient way of increasing hip abduction strength in the clinical setting. It would be useful to analyse **which exact muscles were being targeted** and **if this is such an effective exercise.**
Reiman et al. (2012)	A literature review of studies evaluating Glut Max and Glut Med activation during rehabilitation exercises. Note: Healthy subjects	**Changes in the trunk position, movement direction, and base of support** can affect EMG activity Most effective: **Glut Max: Forward step-up** **Glut Med: Side bridge to neutral position**
Jacobsen et al. (2012)	Is eccentric hip abductor weakness present in patients with symptomatic external snapping hip compared with healthy matched controls.	**Hip abduction strength training with an eccentric emphasis may reduce or delay the need for surgery** for patients with external symptomatic snapping hip.
Willcox and	Influence of varying hip angle and	**A neutral pelvis position was advocated to**

Burden, (2013)	pelvis position on muscle recruitment patterns of the hip abductor muscles during the clam exercise	**optimize recruitment of the Glut Max and Glut Med during the clam exercise**. Further, **increasing the hip flexion** angle increased activation of the **Glut Med.** **ALERT: Different to Grimaldi**
Lee et al. (2013)	Effects of different hip rotations on Glut Med and TFL muscle activity during isometric side-lying hip abduction	**Frontal side-lying hip abduction with medial rotation** resulted in **greater Glut Med muscle activation** and a higher Glut Med: TFL muscle ratio.
Selkowitz et al. (2013)	Which exercises were best for activating the Glut Med and the superior portion of the Glut Max, while minimizing activity of the TFL.	The **clam, sidestep, unilateral bridge, and both quadruped hip extension** exercises would appear to be the most **appropriate.** **ALERT: Different to Grimaldi**
Lee et al. (2014)	Different hip rotations influence hip abductor muscles activity during isometric SHA in subjects with Glut Med weakness.	**SHA-MR can be used as an effective method to increase Glut Med activation and to decrease TFL activity** during SHA exercises. **ALERT: Different to Grimaldi**
Barton et al. (2014)	Gluteal muscle activation during the isometric phase of squatting exercises with and without a Swiss ball.	**SLS may be more appropriate than DLS to facilitate strength gains of Glut Med and Glut Max**. Additionally, the Swiss ball may be a useful adjunct to target gluteal muscle strengthening during SLS.
Dieterich et al. (2015)	Differentiation of GMed and Min activity in WB and non-WB exercises by M-mode ultrasound imaging	**WB exercises** promoted a greater functional differentiation **between deep and superficial hip abductor muscles.**
Stastny et al. (2016)	How to implement Glut Med strengthening in heavy resistance training programs,	After the identification of Glut Med weakness, a selection of Glut Med exercises may be applied to a **beginner's** or **advanced resistance training workout (using a HHD)** as described in this study.
Moore et al. (2019)	Rehabilitation exercises for the Glut Med muscle segments - an EMG study.	**Open-chain hip abduction and SLS exercises appear to be effective options for recruiting the individual Glut Med segments**. **The side-lie clam however doesn't appear to be effective at recruiting the Glut Med segments** particularly the anterior and middle segments. **Alison Grimaldi comment**: "Does **activate posterior Glut Med & Min well but very low levels in anterior portions of these muscles** Need to have exercises that activate anterior portions or both together".

SLS: single-legged squatting; DLS: double-legged squatting; Glut Med: Gluteus Medius;

Glut Max: Gluteus Maximus; SHA: Side-lying Hip Abduction; SHA-MR: SHA with hip medial rotation; GT: Gluteal Tendinopathy; TFL: Tensor Fascia Latae; WB: weight-bearing; HHD: HandHeld Dynamometer; NWB: weight-bearing; Int: Internal; Ext: External;
EMG: Electromyographic.

Table 16 shows the contrasting outcomes regarding abduction exercises and the specific role it plays regarding Gluteus Medius.

Slide 226

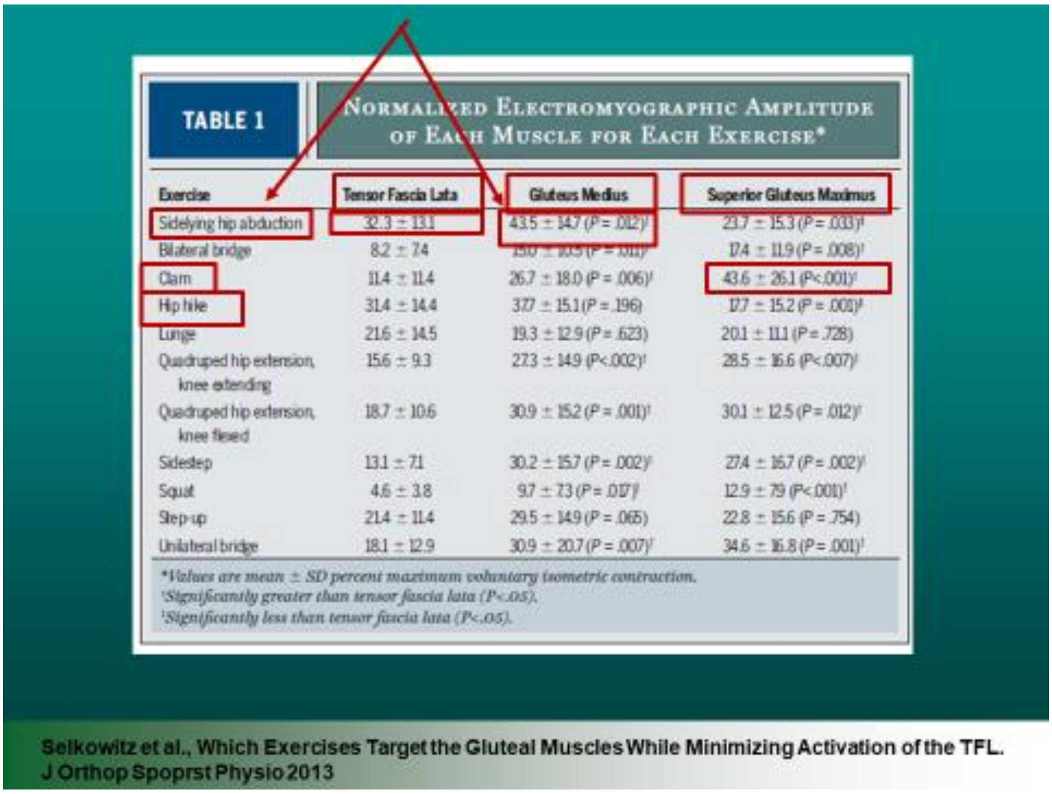


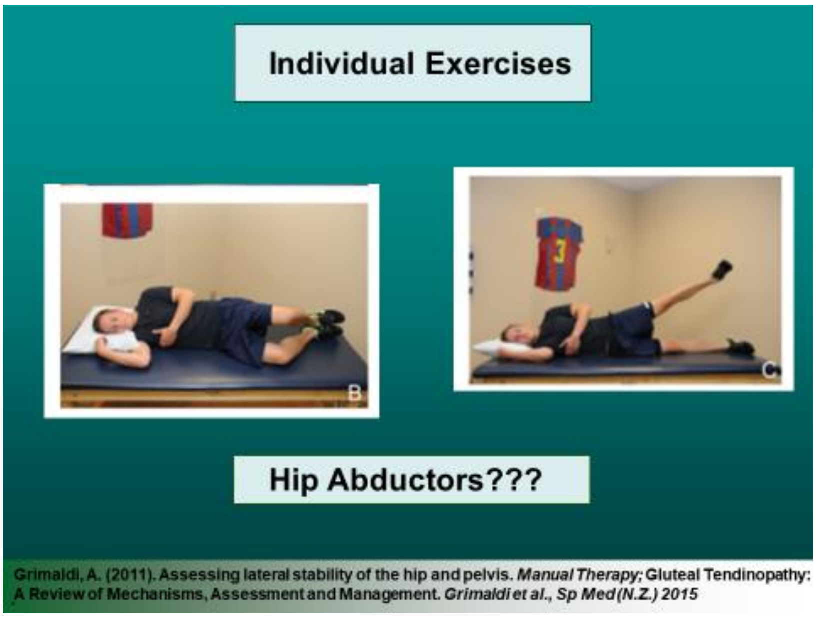
TABLE 1 Normalized Electromyographic Amplitude of Each Muscle for Each Exercise*

Exercise	Tensor Fascia Lata	Gluteus Medius	Superior Gluteus Maximus
Sidelying hip abduction	32.3 ± 13.1	43.5 ± 14.7 (P = .012)†	23.7 ± 15.3 (P = .033)‡
Bilateral bridge	8.2 ± 7.4	[illegible]	17.4 ± 11.9 (P = .008)†
Clam	11.4 ± 11.4	26.7 ± 18.0 (P = .006)†	43.6 ± 26.1 (P<.001)†
Hip hike	31.4 ± 14.4	37.7 ± 15.1 (P = .196)	17.7 ± 15.2 (P = .001)‡
Lunge	21.6 ± 14.5	19.3 ± 12.9 (P = .623)	20.1 ± 11.1 (P = .728)
Quadruped hip extension, knee extending	15.6 ± 9.3	27.3 ± 14.9 (P<.002)†	28.5 ± 16.6 (P<.007)†
Quadruped hip extension, knee flexed	18.7 ± 10.6	30.9 ± 15.2 (P = .001)†	30.1 ± 12.5 (P = .012)†
Sidestep	13.1 ± 7.1	30.2 ± 15.7 (P = .002)†	27.4 ± 16.7 (P = .002)†
Squat	4.6 ± 3.8	9.7 ± 7.3 (P = .017)†	12.9 ± 7.9 (P<.001)†
Step-up	21.4 ± 11.4	29.5 ± 14.9 (P = .065)	22.8 ± 15.6 (P = .754)
Unilateral bridge	18.1 ± 12.9	30.9 ± 20.7 (P = .007)†	34.6 ± 16.8 (P = .001)†

*Values are mean ± SD percent maximum voluntary isometric contraction.
†Significantly greater than tensor fascia lata (P<.05).
‡Significantly less than tensor fascia lata (P<.05).

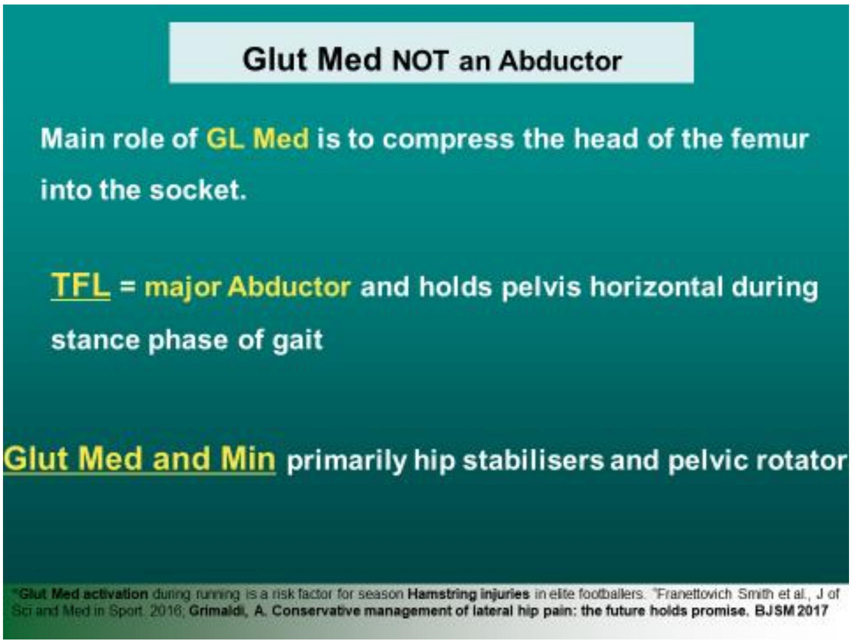
Selkowitz et al. (2013) analysed the specific exercises for Gluteus Maximus, Gluteus Medius and Tensor Fascia Lata. As shown on Slide 226, there is evidence regarding THE best exercise for each muscle e.g. side lying abduction (note the highest Electromyographic activation) which has since been refuted by Grimaldi as below. Also contrary to Grimaldi's opinion, Sidorkewicz et al. (2014) declared that the clamshell may be the preferred rehabilitative exercise to prescribe when minimal Tensor Fascia Lata muscle activation is desired.

Slide 227



According to Grimaldi (2015 and 2017), the Gluteus Medius is not that active in isolated abduction of the hip (Slide 227), although this exercise has been undertaken by clinicians over the past years, specifically for Gluteus Medius and Minimus. Recently, Moore et al. (2019) also commented on the fact that the side-lie clam did not appear to be effective at recruiting the Gluteus Medius segments, particularly the anterior and middle segments. However, they stated that the open chain side-lie hip abduction recorded high activity in the posterior segment and resisted hip abduction– extension exercise generated high to very high activity in the anterior and posterior segments. With these differences in opinion, an ongoing evaluation of all studies pertaining to these exercise is essential.

Slide 228



The role of the Gluteus Medius, Gluteus Minimus and Tensor Fascia Lata has been clearly explained by Grimaldi (Conference, UK. 2015) (Slide 228).

At this stage I think it is important to share some of the comments which I received from Grimaldi via email explaining why she is against the clam exercise (05/05/2017)**.**

- *"Essentially clam exercise tends to strongly facilitate the antero-lateral superficial hip musculature which is often overactive in people with hip pain and/or abductor/ flexor dysfunction. Further it tends to aggravate those with lateral hip pain due to ITB rubbing across greater trochanter.*

- *I believe for a more balanced and natural activation of this antigravity system, gluts are best strengthened in closed chain/weight bearing exercise".*

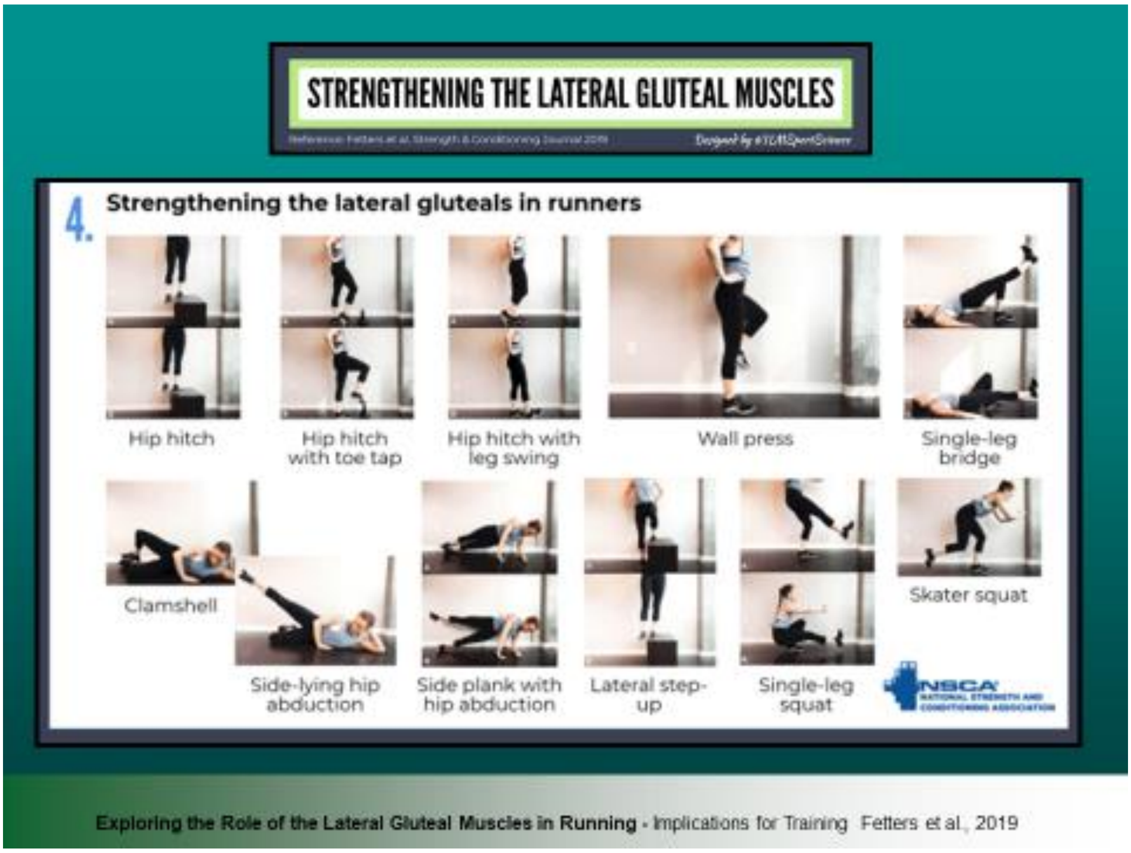
- *People who have done ++ clams and open chain hip abduction exercise appear to develop gross muscle imbalance with +hypertrophy of the anterolateral hip/thigh and relative atrophy of the deeper abductors*

- *So, I definitely wouldn't recommend clam exercise for post scope or gluteal tendinopathy. I don't use this exercise at all, but this is not to say that for some it may be ok as part of a balanced programme".*

Although there is currently no clear evidence to support these comments, I have found that as per my case study discussed on page 240, both the clam and side lying hip abduction aggravated my patient with gluteal tendinopathy. Only after a while, with functional exercise performed prior to these specific exercises, did the tendinopathy improve. I believe that the load was decreased on the Gluteal stabilisers with the pathological tendinopathy by not performing the clam and abduction exercise. I believe it is most important to collaborate with specialists such as Grimaldi and even seek out their personal opinion (as opposed to relying totally on studies and / or blogs). Grimaldi definitely shifted my thinking about the hip stabilisers. However, although I take note of her viewpoint and apply where necessary, I don't necessarily exclude the other exercises (clam and sidelying hip abduction) going forward.

An opposing view from Bishop et al. (2018) described their findings where they compared EMG muscle activation of the Gluteus Maximus, Gluteus Medius, and Tensor Fascia Lata while performing 13 commonly prescribed exercises designed to target the Gluteus Maximus and Gluteus Medius. Their findings reported that the clam exercise optimally activated the gluteal muscles while minimizing Tensor Fascia Lata activation. Trammell and Pilson, (2019) explained that although small in size, the Tensor Fascia Lata works with a number of muscle groups to assist in movement and stabilization of both the hip and the knee. It works with Gluteus Maximus and Gluteus Minimus to internally rotate and abduct the hip and with the Gluteus Maximus via the Ilio Tibial band to abduct the hip.

Slide 229



Slide 229 shows the different exercises to strengthen the Gluteus Medius and Minimus (Fetter et al., 2019). In my career, I constantly observe new studies such as this and I use the recommended exercises carefully with ongoing analysis and don't make any immediate drastic changes. The positive response I observe regarding the rehabilitation of the groin or hip pathology amongst my patients are my criteria for proceeding with a certain exercise.

Slide 230

What seems to be a recurring theme is the fact that in order to rehabilitate the Gluteus Medius and Minimus in the most appropriate manner, the functional exercise as shown in Slide 230, whereby the femur is “sucked” into the acetabulum i.e. hip hike, is the most effective strengthening exercise for many hip problems and particularly for any Gluteus Medius tendinopathy. This hip hike exercise is the one I use mostly and have found it to be the most effective for strengthening in a pain free manner. The main stabiliser of the hip is Gluteus Medius (with Gluteus Minimus) and thus training the stabilizers of the hip is crucial for prevention or rehabilitating any pathologies around the groin or hip. This also has benefits for lower limb pathologies such as symptomatic valgus knee(s).

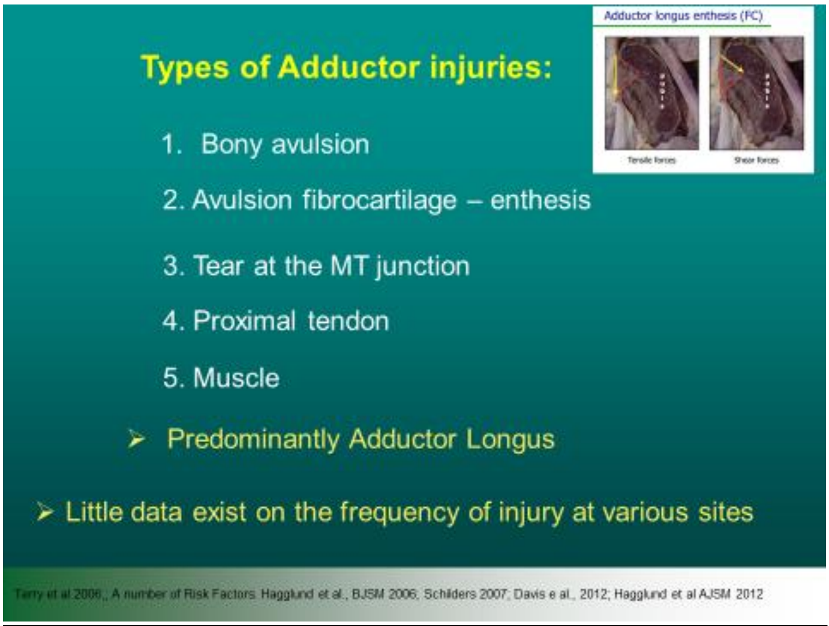
As time goes on, more evidence is suggesting that for rehabilitation of hip problems, one should first address the hip stabilisers, then Gluteus Maximus retraining before moving on to specific strength training, as was suggested by Brukner and Kahn, (2017).

In conclusion, regarding Gluteal muscles, I am bemused by the fact that, whereas “Pilates” and “core stability” have been the well marketed and targeted zone internationally, clinicians are now realising that this is only one aspect for body conditioning and load transference. Through their attachments to the thoracolumbar fascia, the Glutei muscles are also involved in core stability. Strengthening of the Glutei muscles (as well as adductors and all pelvic related muscles) is a key factor in management of the entire body, as well as the groin and hip.

- **Hip Adductors**

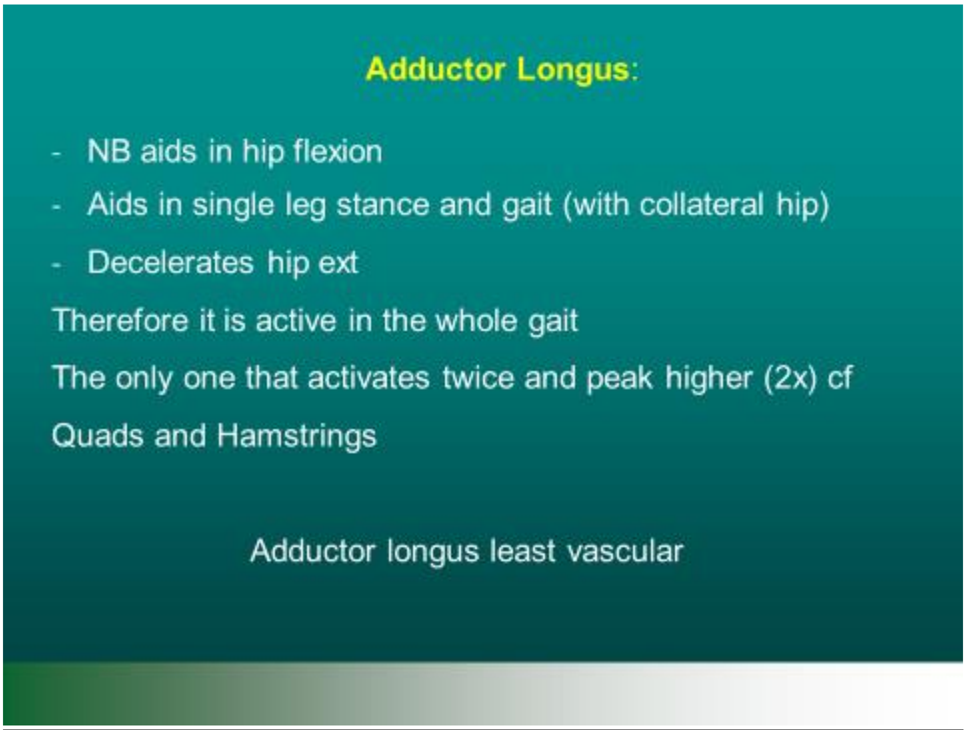
The hip adductor muscles play an important role in both movement and stability at the hip joint in many athletic pursuits and Adductor-Related Groin Pain is the most common clinical finding in soccer players with groin pain (Thorborg et al., 2014). The hip adductor muscles are the second most common muscle injury location in football (Ekstrand et al., 2011) and account for two-thirds of acute groin injuries in athletes, with the adductor longus injured in 90% of these cases (Serner et al., 2015; Serner et al., 2018; Serner et al., 2019).

Slide 231

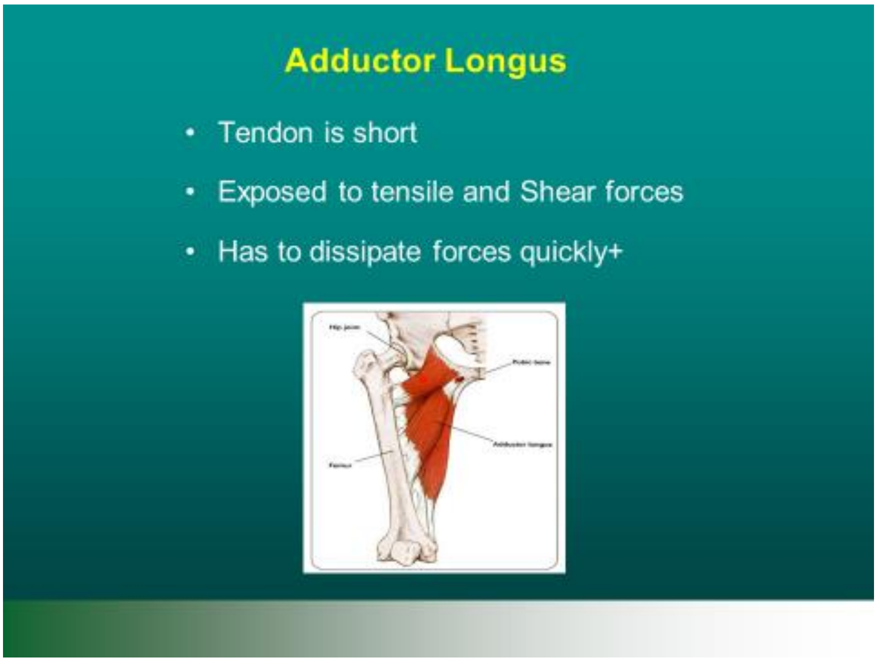


An intimate knowledge of the anatomy of adductor muscles should clarify the different types of adductor muscle injuries and may help with subsequent management (Slide 231).

Slide 232

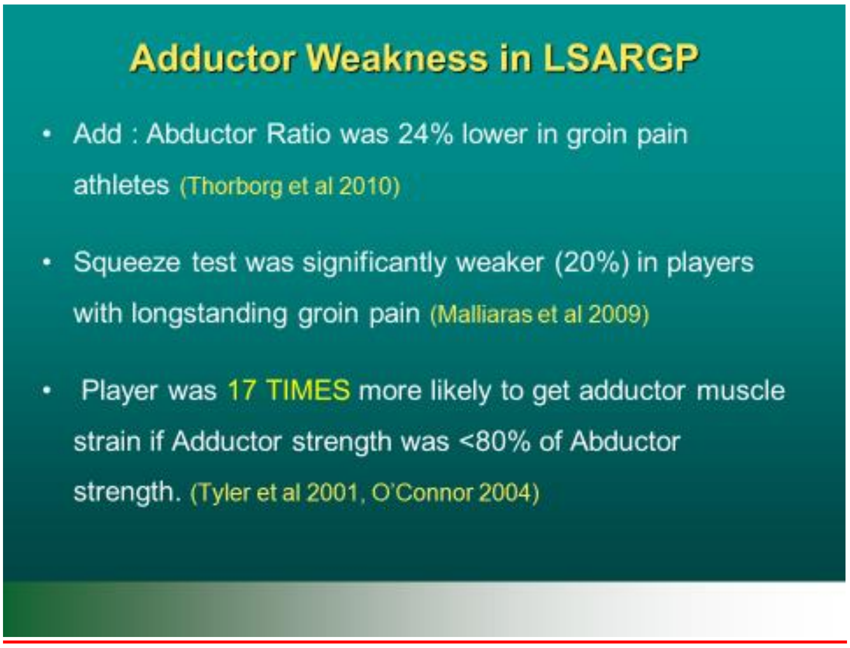


Slide 233



As explained by Jon Fearn (2012), the intricacies of Adductor Longus and the multifaceted function of this muscle may indicate, in part, why Adductor Longus is the adductor muscle most prone to injury (Slides 232 and 233). This was further verified by Dr Bryan English at the NIESSEM medical meeting (Hartlepool, England, United Kingdom (2016).

Slide 234



Slide 234 shows the impact of long standing adductor related groin pain on the strength of the adductor muscles. This information is now mostly recorded in elite sport as a preventative strategy.

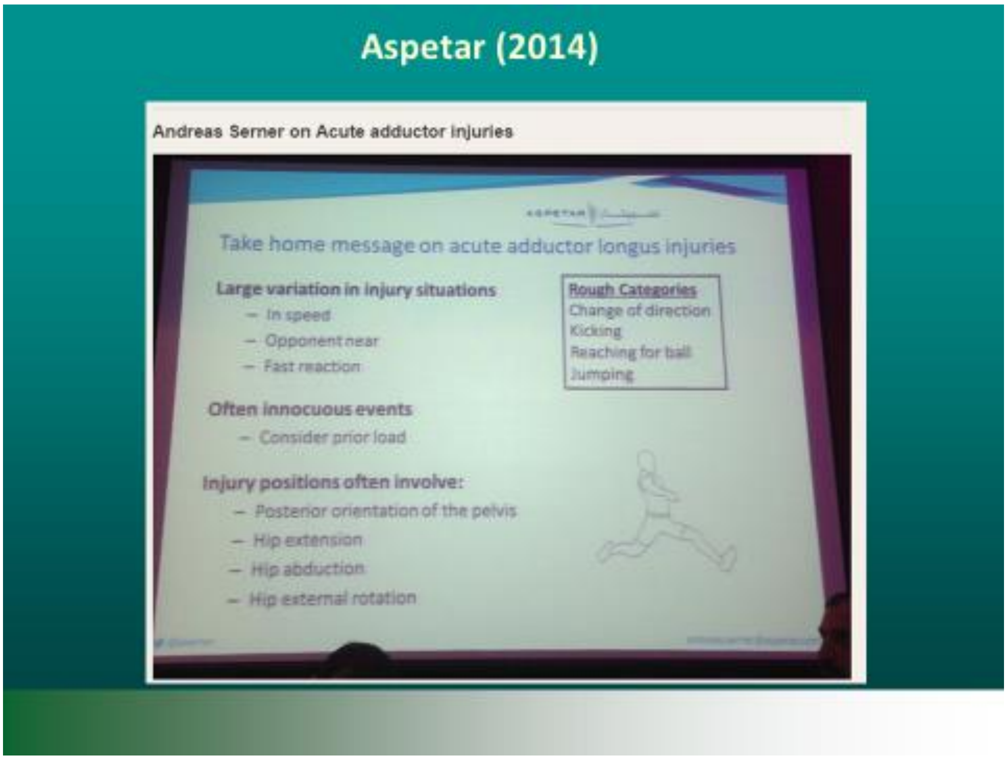
Table 17: Importance of Adductor strength

Author	Population	Outcome
Hrysomallis (2009).	The review was based on articles identified by computerized searches using MEDLINE (January 1966 to September 2007) and SPORTDISCUS January 1966 to September 2007) databases.	There is some evidence to suggest **that decreased flexibility and weakness of the adductor muscles are related to injury risk** in particular sports and that an intervention program may be effective in reducing injury risk
Crow et al. (2010).	Elite under-age Australian footballers	**Decreased hip adductor strength preceded groin injury.**
Engebretsen et al. (2010).	508 male soccer players representing 31 amateur teams	A history of acute groin injury and **weak adductor muscles** are significant risk factors for new groin injuries.
Thorborg, (2011).	Nine elite soccer players (19.4 years) and nine recreational athletes (19.5 years).	**Eccentric hip adduction strength was greater in the dominant leg** than in the non-dominant leg but not in matched controls.
Schilders, (2013).	Professional athletes who received a selective partial adductor release	**Adductor strengthening is an essential part of treatment at prevention level** and as part of conservative treatment or post-surgical repair.
Norton-Old et al.	Bilateral dissections were	Showed the anatomical relationship between the

(2013).	conducted on 10 embalmed cadavers	proximal adductor longus (AL) and rectus abdominis (RA) muscles and determined that unilateral loading of AL resulted in strain transmission across the anterior pubic symphysis to the contralateral distal rectus sheath **supporting the interconnectedness of the tendon attachments.**
Jensen et al. (2014).	Thirty-four healthy, sub-elite soccer players, mean (±SD) age of 22.1 (±3.3) years	**Hip adduction strength is** important for kicking and acceleration in soccer players. Adductor pain **without strength loss** is commonly associate with a hip condition such as **dysplasia or FAI.**
Thorborg et al. (2014).	Male elite and sub-elite players from 40 teams were contacted. 28 soccer players with adductor-related groin pain (ARGP) and 16 soccer players without ARGP (asymptomatic controls) were included in the study.	**Large eccentric hip adduction strength deficits were found in soccer players with ARGP** compared with asymptomatic soccer players, while no isometric strength differences were observed between the groups. The problem when comparing injured to non-injured groups is that the strength deficits **may also be a result of pain**. Thus results should be interpreted with caution.
Nevin and Delahunt. (2014).	Eighteen Gaelic football players with current longstanding groin pain and 18 matched injury-free controls were assessed on their performance of the adductor squeeze test.	Gaelic football players with longstanding groin pain **exhibit decreased adductor squeeze test** values and hip joint range of motion when compared to non-injured players.
Esteve et al. (2018).	303 male soccer athletes (mean age, 23 ± 4 years) were included in this study.	**Preseason hip adductor squeeze strength is lower in male soccer athletes who have had past-season groin pain** for more than 6 weeks, compared with soccer athletes without past-season groin pain, independent of current groin pain status and age.

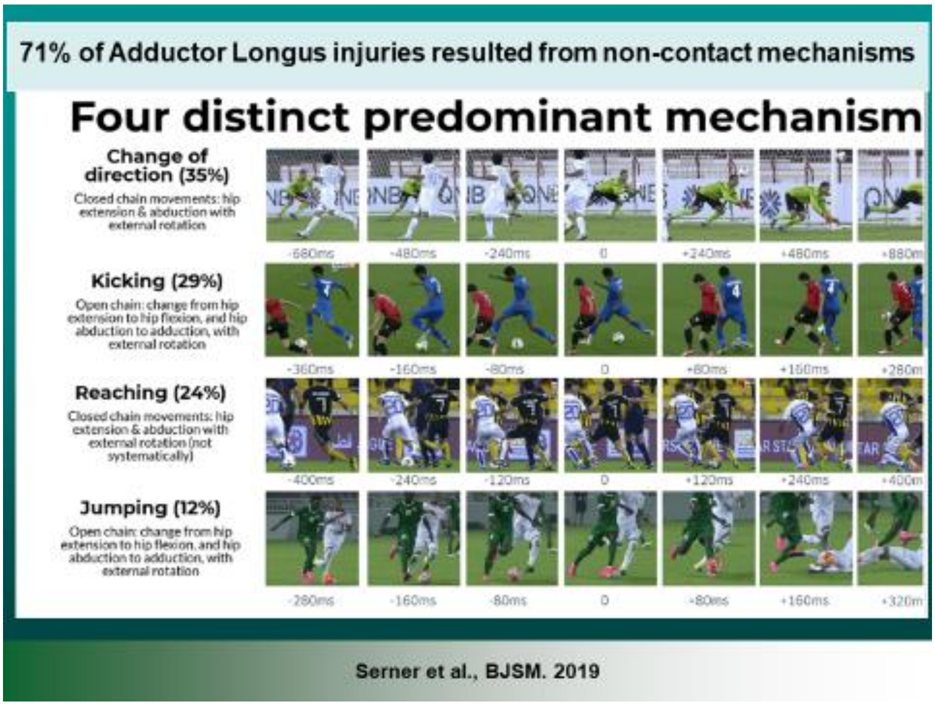
The importance of adductor strength is highlighted in Table 17. The clinician needs to analyse the outcome of these studies and also note that the strength deficits may be a result of pain and not necessarily muscle weakness (Thorborg et al., 2014). Further, the useful outcome in a previous study by Thorborg (2011), is that if the dominant leg is the injured leg in soccer players, the eccentric hip adduction strength of the dominant leg after rehabilitation should rather be 10–15% stronger than the uninjured leg, whereas if the non-dominant is the injured leg, a 10–15% lower eccentric hip adduction strength value after rehabilitation, may be considered normal.

Slide 235



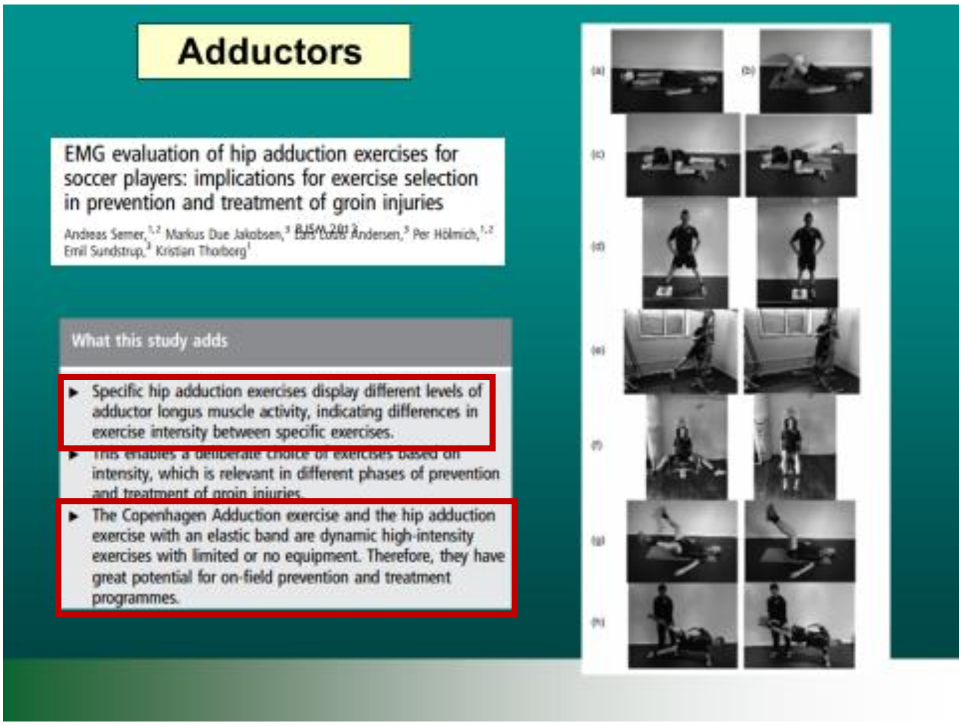
As shown in Slide 235, the clinician requires a thorough understanding of the permutations involved in acute adductor injuries. Serner provided a good overview of acute adductor longus injuries at the groin and hip conference in Aspetar (Doha, Qatar, 2014). He demonstrated in a study evaluating 110 athletes with acute groin injuries that adductor injuries accounted for the majority of the acute groin injuries, with iliopsoas and rectus femoris also being common (Serner et al., 2015).

Slide 236

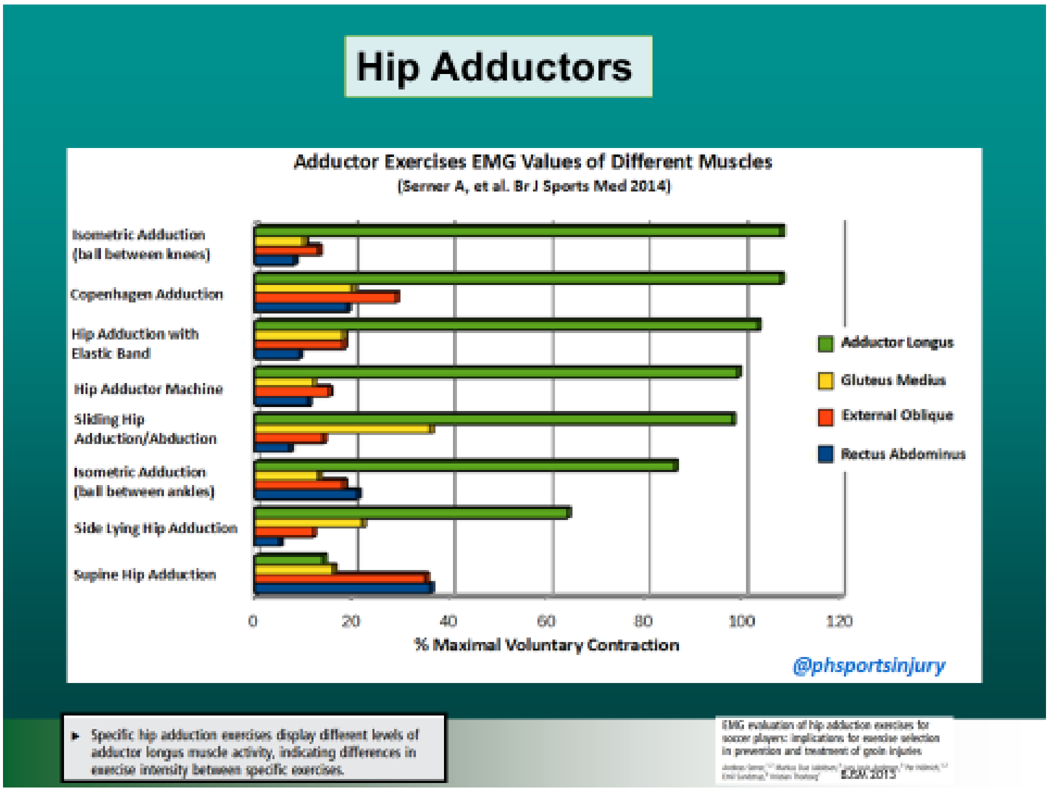


Serner et al. (2019) explained the mechanism of the adductor longus injuries in football and the motion that mostly causes these injuries (Slide 236). These may be prevented and rehabilitated by analysis of these specific movements on the field of play and strengthening accordingly (Slide 236).

Slide 237

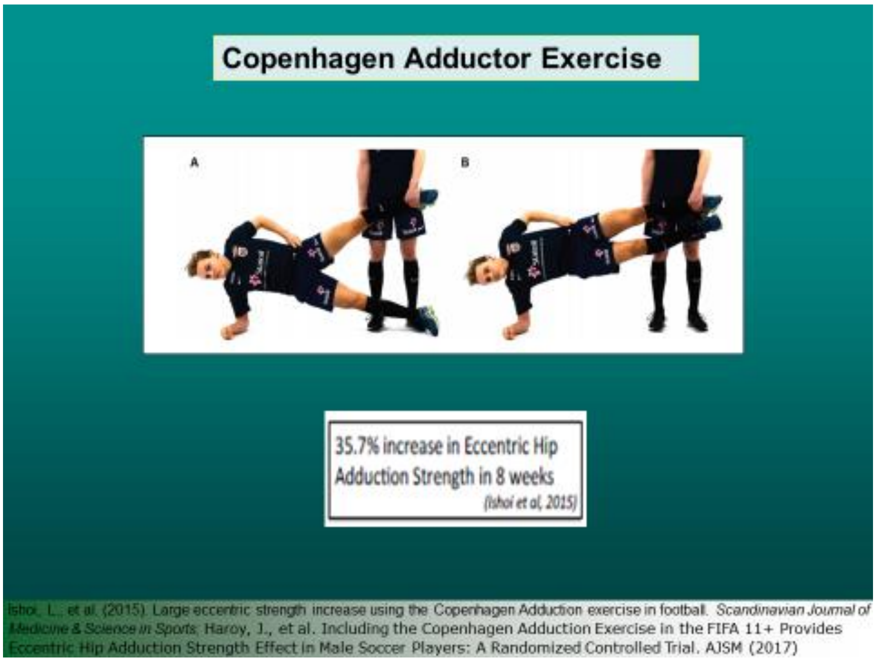


Slide 238



Serner et al. (2014), described the EMG evaluation of hip adduction exercises for soccer players and the resultant implications for exercise selection in prevention and rehabilitation of groin injuries (Slide 237 and Slide 238). Specific hip adduction exercises could be graded by exercise intensity providing athletes and therapists with the knowledge to select appropriate exercises during different phases of prevention and treatment of groin injuries.

Slide 239



Slide 240

The Copenhagen Adduction and the hip adduction exercise with an elastic band are proven dynamic high-intensity exercises (Slide 239 and 240). The Copenhagen Adduction exercise is frequently used in the sports arena with good results (Haroy et al., 2017; Ishoi et al., 2016). I have had positive outcomes from these 2 exercises and appreciate the fact that they can easily be performed at any training facility (as per my work in the disadvantaged community).

Table 18: Adductor muscle exercises

Author	Outcome
Schlegel et al. (2009).	**Non-operative treatment of proximal Add tendon rupture resulted in a statistically significantly faster RTP** than operative treatment in athletes competing in the National Football League. The **non-operative treatment algorithm (including exercises) differed** in each case because of the number of teams and providers involved and the differing individual responses of each player to treatment.
Thorborg et al. (2011).	Knowledge of the **side-to-side eccentric hip adduction strength difference in soccer players is relevant** when undertaking rehabilitation of injured soccer players.
Brandt et al. (2013).	Elastic resistance and exercise machine seem equally effective for recruiting muscle activity of the hip adductors. However, **the elastic resistance condition was able to demonstrate greater muscle recruitment than the exercise machine during hip abduction.**
Franklyn Miller, (2014)	**Functional movement involving the pelvic and hip area** and the relevant kinetic chain involved has been shown to have the greatest effect.
Jensen et al. (2014).	8 weeks of hip-adduction strength training, using elastic bands, **induced a relevant increase in eccentric hip-adduction strength in soccer players.**
Delmore et al. (2014).	This study provides a ranking system on the activation levels of the AL muscle for 6 common hip-adductor rehabilitation exercises, **with the side-lying hip-adduction and ball-squeeze exercises displaying the highest overall activation.**
Hides et al. (2016).	**Add Mag and AL muscles were recruited to different extents during a simulated WB task**. CC with WB through the lower limb are more likely to recruit the Add Mag muscle over the Add Long muscle.
Ishoi et al. (2016).	**Copenhagen Adduction exercise** implemented in-season with an 8-week progressive training program elicited a large significant increase in EHAD, EHAB and EHAD/EHAB ratio.
Obey et al. (2016). **Reaffirmed** by Philippon et al. (2015);Tosovic et al. (2016); Storey et al. (2016) and Broski et al. (2016).	Detailed **knowledge of the Add Mag tendon anatomy**, footprint anatomy, and its relationship to the hamstring muscle complex is paramount when planning rehabilitation strategies. Thus the rehabilitation protocol must be structured accordingly.
Haroy et al. (2017).	The **Copenhagen Adduction exercise** should be included in the FIFA 11+ program as it increases eccentric hip adduction strength, while the standard FIFA 11+ program did not.

Add: Adductor; AL: Adductor Longus; Add Mag: Adductor Magnus; RTP: Return to Play; CC: Closed chain exercises; WB: Weight-bearing; EHAD: Eccentric hip adduction strength; EHAB: Eccentric hip abduction strength

Table 18 demonstrates the general consensus for rehabilitating the Adductor muscles.

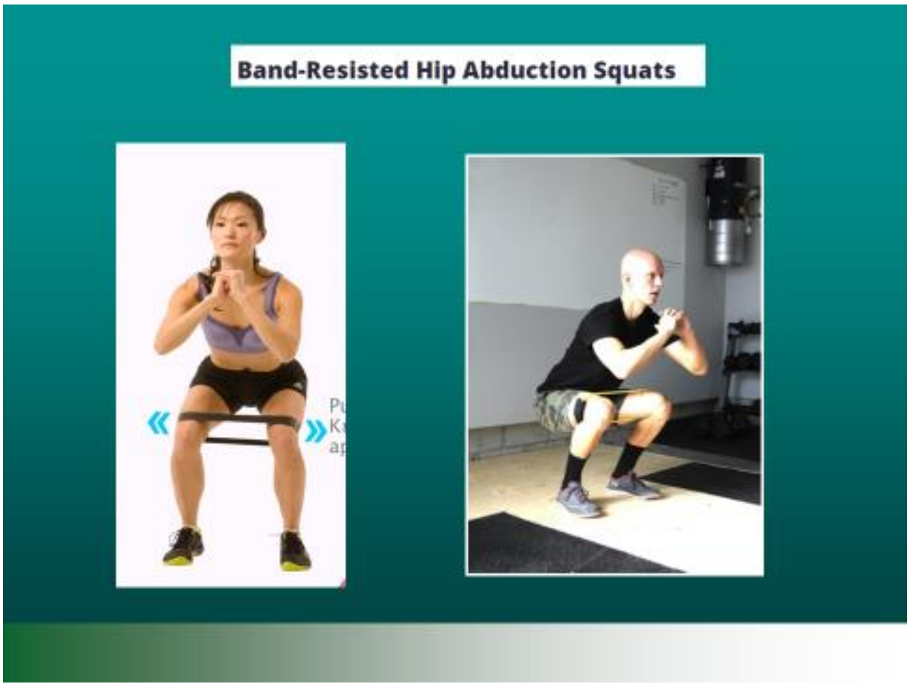
Slide 241

From my perspective and experience, the Adductor muscles should not be the sole focus of rehabilitation. They should be incorporated in most general exercises regimes in order to enhance the neuro-motor component and the incorporation of the adductors into most patterns of movement. In Slide 241, exercises which have been recommended by clinicians in various conferences / studies are shown. In my presentations, I discuss the permutations of each exercise as above, with their lack of engagement of the adductor muscles (bottom picture) or poor posture (first picture). It would be of great benefit if these nuances were considered and would assist the feedback / feedforward pattern and consequential good model of movement, as discussed previously.

Slide 242

I thus have always incorporated adductor muscles in most exercises, be-it general training in the gym or for rehabilitation (Slide 242).

Slide 243



However, as has been stated previously, every athlete / patient must be individualised. Thus if an athlete (often female) has internal hip rotation and genu valgus of the knees, I would not do as on Slide 242, incorporating the adductor muscles at all times, but train the muscles in the correct alignment (Slide 243). I would still assess and strengthen any weakened adductor muscles accordingly.

In conclusion, regarding Hip Adductors, I would like to add that in my presentations I spend much time on the value of the Adductor muscles, hence the many slides which I choose depends on the attendees. It is interesting to note that it is only in recent years that clinicians are aware of their significance in the body movement integration and efficient kinetic control.

- **Hip Flexors / Piriformis / Abdominals**

Hip flexor injuries account for one-third of acute groin injuries. However, little is known about specific injury characteristics (Serner et al., 2018).

Table 19: Hip Flexors / Piriformis / Abdominals

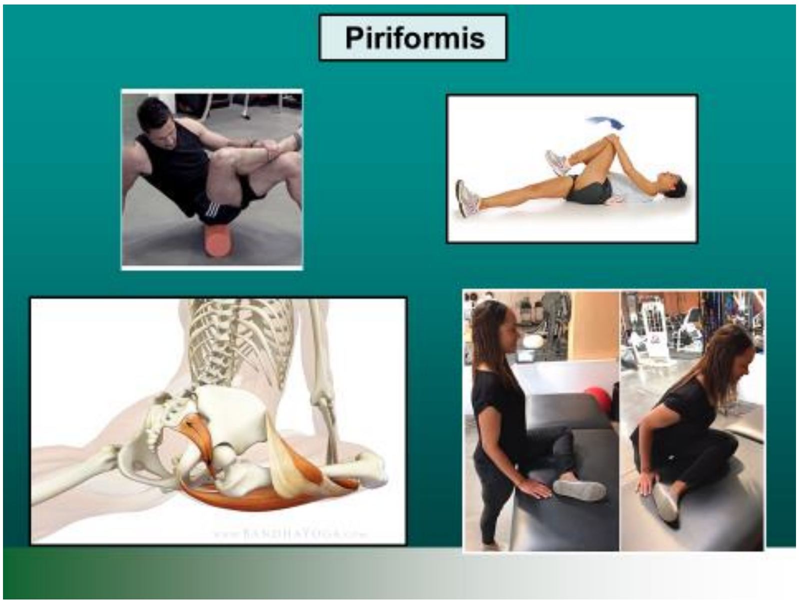
Author / Journal	Outcome
Giphart et al. (2012).	The **pectineus and piriformis muscles function as hip-stabilizing muscles** and may be used to specifically address pectineus and piriformis muscle rehabilitation Pectineus was highly activated during hip flexion exercises and moderately activated during exercises requiring rotational hip stabilization in either direction, rather than with internal hip rotation only. The piriformis was most activated during static external rotation and abduction while the participants' hips were in slight extension.
Sundstrup et al. (2012).	**Swiss ball abdominal crunch** with added elastic resistance was an effective alternative to training machines. It induced **high RA activity accompanied by low hip flexor activity.**
Mendis et al. (2014).	**Change in hip flexor muscle size, strength and recruitment patterns in patients with acetabular tears.** Hip flexor muscles contribute to hip joint stability and function and **decreased hip flexor muscle strength affects physical function in patients with hip labral pathology by contributing to altered gait patterns and functional tasks.** **Important to note this and incorporate into rehab strategy**
Mohammad et al. (2014).	Concentric weakness of back muscle **and eccentric weakness of abdominal muscles** noted that led to disturbance of the normal concentric abdominal/back ratio. **Assessing abdominal and back muscle strength** is a crucial step in the evaluation of patients with "osteitis pubis" (or groin pain) and consequential specific strengthening.
Thorborg et al. (2015).	**Simple hip-flexor strength training using elastic bands** as external loading for only 6 weeks, improved the hip muscle strength by an average of 17 %.
Serner et al. (2017).	**Whether the injury is musculo-skeletal or tendinous and the exact location**, this factor is important in terms of rehabilitation time and RTP. The **iliacus or psoas major** may be injured during change of direction, whereas **RF** injuries occur primarily during kicking or sprinting. **These factors need to be considered for late stage rehabilitation.**
Chan et al. (2017).	**Abdominal core activation enhances the hip muscles recruitment in Clam, HABD and PHE exercises, and this enhancement is correlated with higher physical activity and stiffer hip muscle**. Their results suggest the potential application of abdominal core activation for lower limb rehabilitation, as the increased activation of targeted hip muscles may enhance the therapeutic effects of hip strengthening exercises.
Tsang et al. (2018).	These findings indicated the presence of **co-activation of the abdominal and hip muscles when performing the free active hip exercises** i.e. enhanced IO/TrA contraction resulted in significantly greater activity in Gluteus Maximus, Gluteus Medius and Bicep Femoris at various phases of hip extension and clam exercises, single leg sit-to-stand and pelvic drop exercise.

RTP: Return to Play; RF: Rectus Femoris; RA: Rectus Abdominus; IO: Internal Oblique;

TrA: Transversus Abdominis.

The importance of the hip flexors, piriformis and abdominal muscles are highlighted in Table 19 and their functionality should be analysed and considered for rehabilitation and prevention strategies.

Slide 244



The piriformis is an external rotator when the hip is extended and an internal rotator when the hip is flexed and is often underestimated in rehabilitation. My experience with sports people has shown me that tight piriformis seems to be a common problem in many athletes and is often the basis for groin problems. Rehabilitation of this muscle is important and would include specific stretching exercises (plus the use of a foam roller) and correct activities of daily living - particularly incorrect or prolonged sitting positions (Slide 244). Core and gluteal muscle strengthening, gait correction and specific sport technique correction are part of the rehabilitation.

Conclusion: Specific exercises and implications.

As well as an understanding of anatomy and functional anatomy, I suggest that clinicians take cognisance of the different permutations of various exercises and the resultant effect on specific muscles and their action. For a positive outcome, the clinician can analyse the evidence based medicine and note that different exercises have different muscle activation and certain factors such as hip range of movement may produce varying outcomes. This section shows the importance of assessing and rehabilitating specific muscles, as well as considering the synergic muscles involved. I find that continuous analysis of the outcomes of each exercise with different patients is a useful factor in my rehabilitation protocols.

8j. "FAI"/FAIS and Rehabilitation

8j i. Background

FAI/FAIS and rehabilitation is currently a highly topical debate internationally and thus requires specific mention in this section. As discussed in Chapter 7 – Surgery, certain anatomic abnormalities/ morphologies such as Cam, Pincer, or combined lesions, increase the risk of symptomatic FAI by decreasing the safe functional range of motion. These repetitive motions of hip with morphological changes can lead to multiple intra-articular pathologies. As has been discussed, this understanding of the impairments associated with Cam or Pincer morphology / FAIS is crucial for prevention and rehabilitation strategies.

The literature has given little attention to the non-operative management of hip morphologies / FAIS despite a rapidly expanding body of research on the topic.

8j ii. "FAI" / FAIS - Biomechanical Mal-Adaptations and Muscle Weakness

One needs to understand and process the possible biomechanical mal-adaptations and muscle weakness in athletes with hip morphology or FAIS.

A number of constant factors emerge from many studies, as shown in Table 19.

Table 20 "FAI"/ FAIS - Biomechanical Mal-Adaptations and Muscle Weakness

Author	Outcome
Casartelli et al. (2011).	Future research should investigate the relationship between **hip muscle weakness, functional disability and overuse injury risks**, as well as the **effects of hip muscle strengthening** on clinical outcomes in individuals with symptomatic FAI.
Hunt et al. (2013).	Individuals with FAI exhibit **differences in gait kinematics in all planes of motion compared to those without FAI.** These findings support the need for focused **neuromuscular reconditioning.**
Hetsroni et al. (2015).	Young adult men with cam-type FAIS **present excessively inverted hindfoot at the moment of heel strike** and reduction in maximum eversion during the stance phase

Diamond et al. (2016).	**Individuals with FAIS have minimal impairments in gait biomechanics.** Although these individuals demonstrate reduced hip joint motion in the sagittal plane, the size of the difference is small and its significance for symptoms and function is unclear
Diamond et al. (2016).	Individuals with symptomatic FAI demonstrate **isometric hip abductor muscle weakness and strength imbalance in the hip rotators**.
Hammond et al. (2017).	Those with **FAI exhibit greater peak trunk forward flexion angles, increased external hip flexion moments, and decreased peak external knee flexion moments** compared to the healthy control group
Grammatopoulos et al. (2018).	**Symptomatic hips had a greater amount of supero-posterior coverage**; which would be the contact area between a radial cam and the acetabulum, when the hip is flexed to 90°.
Rutherford et al. (2018).	**Individuals with FAI were generally deconditioned and reported significantly more functional limitations. Hamstring and G Max activation differed when the symptomatic group was compared with the asymptomatic group.**

FAI: Femoro-Acetabular Impingement; FAIS: Femoro-Acetabular Impingement Syndrome.

The above table (20) consistently shows the mal-adaptations and weaknesses observed in patients with hip morphologies / FAIS. Further studies explaining the formation and possible resultant impairments due to Cam and Pincer morphology include Agricola, (2016); Anderson et al. (2016); Botha et al. (2014); Diamond et al. (2016); Freke et al. (2016); Palmer et al. (2017); Tranovich et al. (2014) and Weir et al. (2011).

Thus proposed exercises for observed weaknesses are relevant for productive rehabilitation, as well as a prevention strategy.

8i iii. FAI and Conservative Treatment

Table 21: FAI and Conservative Treatment

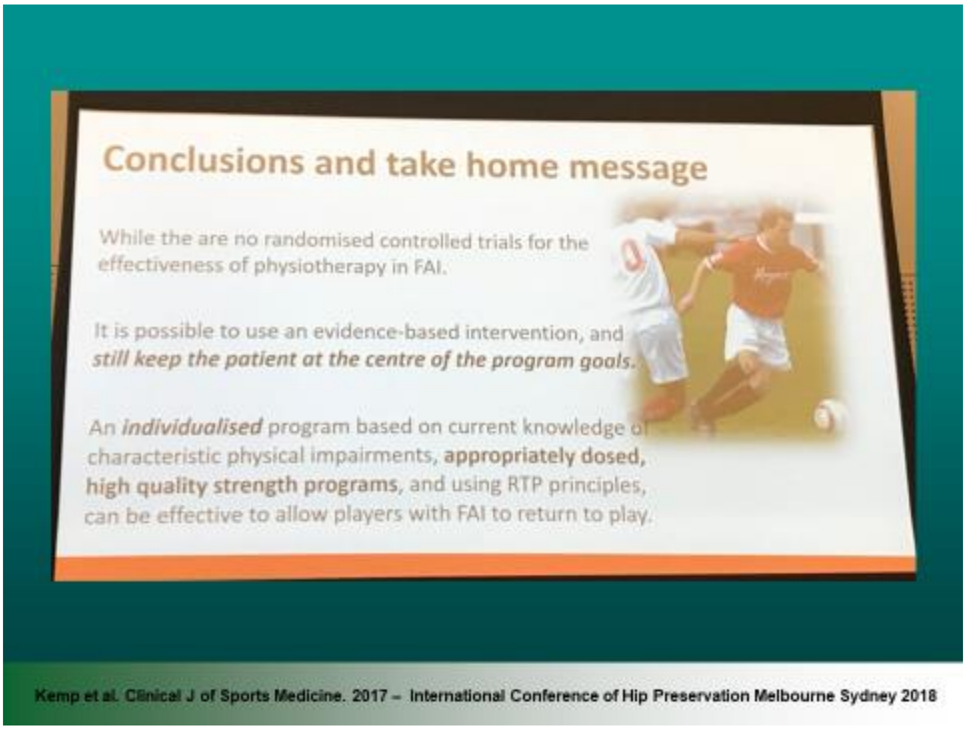
Author	Outcome
Wall et al. (2013) and Loudon and Reiman, (2014).	Physical therapy and activity modification **may confer some benefit to patients**
Kemp and Crossley, (2014).	The evidence supporting the best **conservative management for FAI is limited.** Conservative management of FAIS focuses on decreasing adverse hip loads through the implementation **of hip muscle strength programmes and modification of external joint loads**. Suitable rehabilitation strategies may have the potential to modify hip joint loads and potentially mitigate the progression of hip and groin pain in FAIS.

Gard et al. (2015).	Conservative treatment should not focus on forcing the full range of motion, but on **restoring a good muscle balance around the joint and a better lower limb dynamic stability and control.** The patient should be educated to master the end of hip range of motion during his activities.
Loudon and Reiman, (2014).	**Physical therapy and activity modification** may confer some **benefit** to patients.
Yazbek et al. (2011); Hunt et al. (2012); Yuill et al. (2012); Sebastian and Trousdale, (2013); Mansell et al. (2016).	There is a **need to determine the impact of surgical and non-surgical treatments** on long-term clinical results
Wright et al. (2016).	Common advice included **avoidance of long term sitting, crossing the legs, pivoting, deep squats, and cycling at increased angles of hip flexion**. In terms of home exercise, all patients received a "hip handout" at the time of the initial evaluation consisting of six exercises. **Physical therapy interventions show positive effects** in decreasing pain in patients with FAI.
Pennock et al. (2018)	**82% of adolescent patients presenting with FAIS can be managed non-operatively**, with significant improvements in outcome scores at a mean follow-up of 2 years. A non-operative approach should be the first-line treatment for young active patients with symptomatic FAIS
Casartelli et al. (2018)	It has been hypothesised that **improving dynamic stability of the femoro- acetabular hip joint** as a result of active NM training may lessen the mechanical loads on the hip joint structures and reduce the symptoms in some patients. At present, it is **not clear what comprises the best non-surgical management for FAIS** and also, which patients could most benefit from non-surgical protocols. There is no level 1 evidence available today.
Kemp et al. (2018)	A FAIS-specific physical therapy program **has the potential for a moderate to large positive effect on hip pain, function, and hip adductor strength.**
Young et al. (2019).	Surgery for FAIS has risen significantly in recent years, but **little is known about physical therapy utilization prior to surgery. Further research is needed to understand the reasons for poor utilization and better define failed non-operative management.**
Palmer et al. (2019).	This study compared arthroscopic hip surgery with physiotherapy and activity modification for improving patient reported outcome measures in patients with FAIS. Participants in the physiotherapy group received a goal based programme tailored to individual patient needs, with emphasis on improving core stability and movement control. A maximum of eight physiotherapy sessions were delivered over five months. The outcome showed **superior outcomes with arthroscopic hip surgery than with physiotherapy and activity modification**.

FAI: Femoro-Acetabular Impingement; FAIS: Femoro-Acetabular Impingement Syndrome.
NM: Neuromuscular.

Table 21 shows that there is a real need for more valid studies to show rehabilitation for FAIS. In these studies, the exact exercise programme is not clear e.g. “an initial trial of rest, physical therapy, and activity modification” (Pennock et al., 2018). Further, much depends on which physio prescribed the exercise programme and the consistency of the physio involved and the actual treatment e.g. “a maximum of eight physiotherapy sessions was delivered over five months” (Palmer et al., 2019).

Slide 245



An excellent presentation by Kemp (International Conference on Hip Preservation, Melbourne, Australia. 2018) gave an explicit practical conclusion to her studies and highlighted the value of individualising each rehabilitation protocol (Slide 245).

An important factor which need to be investigated is that of FAIS prevention in order to protect the hip of the growing athlete (Gard et al., 2015).

Summary – FAI / FAIS Conservative Treatment

Due to this potential debilitating sequence of events, Cam and Pincer morphology / FAIS is currently a very pertinent topic. Going forward, I would recommend a specific strengthening /

stabilising / neuromotor control programme for all athletes with any Cam / Pincer morphology, regardless of whether they are symptomatic. I have been using a number of the exercises, especially those that highlight hip stability (which were explicitly described above) with good success and also correcting all the mal-adaptations and strengthening accordingly. I have practically noted the positive outcome even though evidenced based research is required. Thus there is currently no evidence that one specific exercise protocol may prevent asymptomatic morphologies from developing into symptomatic pathologies and ultimately OA. Further, an optimal training programme (with evaluation of load) is advised in child athletes to prevent the development of Cam morphology in the first place, as advised by all specialists in this field.

8k. Progression of Exercises

Slide 246

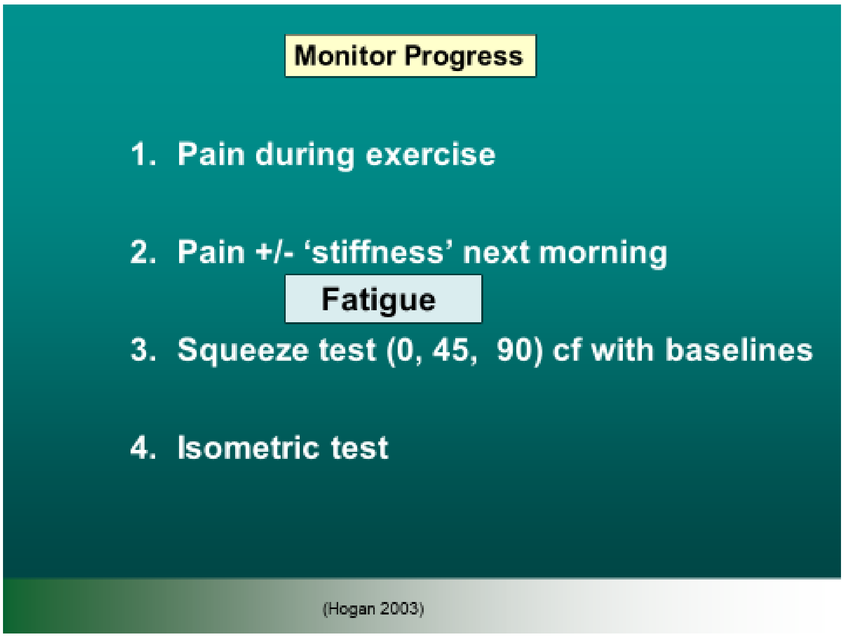
Apart from processing each individual's requirements such as goals, type of sport, psychological make-up and socio-economic conditions, progressing the rehabilitation requires moving from indoors to outdoors, as well as factoring in the fatigue component (Slide 246).

8l. Monitor progress

Slide 247

Slide 247 shows my involvement with the Super 14 rugby team and the progressive exercises undertaken. It is important that an athlete maintains cardiovascular fitness during rehabilitation of a hip or groin injury. The mode of training will depend on a number of factors including what equipment is available, the patient's competency in that situation and what does not aggravate the injury, as well as the specific phase of the rehabilitation. Generally, the athletes are able to do alternative training e.g. cycling or specific pool work.

Slide 248



Critically, one should monitor the progress on an ongoing basis during rehabilitation and throughout the season after sustaining hip or groin pain (Slide 248). I believe that progress needs to be measured by objective tests throughout the athlete's rehabilitation. Tests such as the SEBT and the squeeze test as shown in Chapter 5 - Tests, are most useful to objectively score groin pain and proprioception/balance scores.

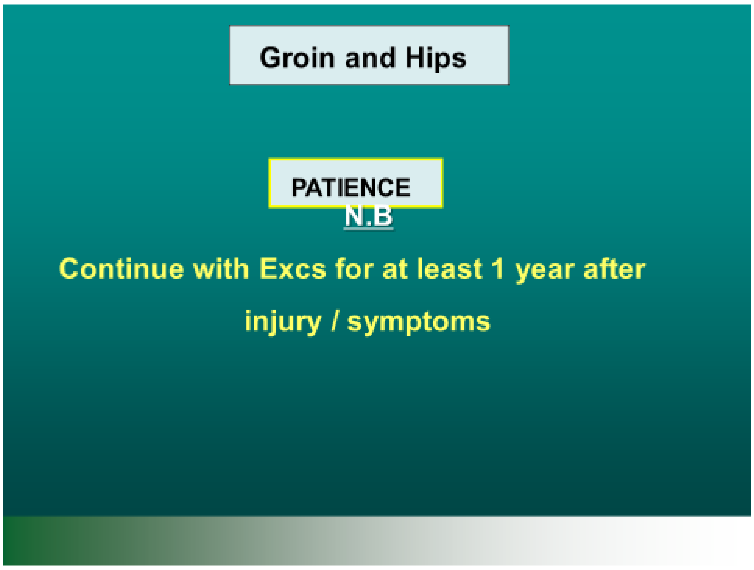
One also needs to identify when a patient has reached a plateau in their rehabilitation or when a certain aspect of the rehabilitation (e.g. proprioception) is not progressing at the same time as other components of the rehabilitation. This requires timely and appropriate changes to be made to the programmes. As the groin and hip area sustains so much load in certain sports, I believe that this monitoring should be maintained throughout the athlete's career.

In terms of optimal strength, the comparison from pre-season screening is valuable. Further, when with the Stormers, I collaborated with my rehabilitation colleague (biokinetician) for added input.

I, personally, find that progression is not straightforward in most cases, not only due to the physical factors, but also the psychological factors. Further, when dealing with elite athletes there is constant pressure by the athlete and/or the managerial structure around the athlete to increase the progress in order to return to play as soon as possible. Resisting that pressure is not always easy, but should be ethically mandatory.

8m. Further Considerations

Slide 249



Further, the athlete should be educated as to the length of time required for the rehabilitation protocol, bearing in mind their individual goals. The specific groin and hip exercises should be continued throughout their career, as I have encountered a number of groin and hip injuries that recur, although not necessarily in the same anatomical area (Slide 249). Practically, these specific exercises should be included in the daily fitness regime on an ongoing basis for the full length of time that the athlete participates in his/her respective sport. In my work with the Stormers rugby, I would liase with the Biokinetician (physical trainer) and we would ensure that the specific exercises were incorporated into the general training of all players in the team, regardless of them having any groin or hip problems. This made sure that the injured athlete was not excluded from his team mates whilst being rehabilitated, which is an important psychological factor. It also made all the players strengthen their groin and hip area and may have aided in a preventative strategy. Historically, the majority of athletes have been weaker in those areas and thus it is a most useful prevention strategy. I believe that it may also be of benefit for enhancing their game skills.

8n. Post-Operative Rehabilitation

8n i. Background

The number of hip arthroscopies for the treatment of intra-articular hip pathology has grown, due to a better understanding of the causes and diagnosis of hip pain (Heerey et al., 2018 and Jamil et al., 2018). This has created a need for the evolution of rehabilitation guidelines following these procedures. Hip arthroscopy guidelines exist in the literature with some variability and commonalities and is dependent on the surgeon's preferences and patient access to rehabilitation services. Physiotherapist-supervised rehabilitation is advocated in the literature in order to restore muscle function and strength and improve joint range of motion, as well as facilitate a safe and graded return to sporting activity. Professor Griffin, states that physiotherapy is an integral part of the process of recovery for patients undergoing hip arthroscopy.

Several rehabilitation protocols following hip arthroscopy have been described in the literature.

Table 22: Post-Operative Rehabilitation

Author	Title	Outcome
Cheatham and Kolber, (2012).	Rehabilitation after hip arthroscopy and labral repair in a high school football athlete.	**There is little evidence regarding the rehabilitation of younger athletes** who undergo arthroscopic hip surgery. This case study described a **four phase rehabilitation program** for a high school football player who underwent hip arthroscopy and labral repair – **Initial, Intermediate, Advanced and Sports Specific.**
Cheatham et al. (2015).	Postoperative Rehabilitation After Hip Arthroscopy: A Search for the Evidence.	**This review identified a paucity of evidence on postoperative rehabilitation after hip arthroscopy** It was recommended that a 4- to 5-phase rehabilitation program with a **period of initial restriction in weight bearing** and progression to return to sport at 3 to 6 months Clinicians may consider such a program as a general guideline but **should individualize treatment according to the surgical procedure and surgeon guidelines**.
Malloy et al. (2016).	Rehabilitation after hip arthroscopy: A movement control-based perspective.	- **Initial joint protection** is a hallmark for all patients after hip arthroscopy to prevent intra-articular and extra-articular soft tissue irritation of healing tissues. - Adequate **control of movement** is essential for patients to return to unrestricted function after hip arthroscopic surgery. **Mobility, muscle performance and stability, and NMcontrol** are vital aspects addressed in rehabilitation to help re-establish control of movement for function. - It is essential to tailor exercises of each phase to patients' **specific functional demands**. Each phase of rehabilitation should be **monitored so that patients are not advanced too quickly.**
Domb et al. (2016).	Physical therapy protocol after hip arthroscopy: Clinical guidelines supported by 2-year outcomes.	- **A preoperative program** was initiated 1 month prior to the patients' surgery. - 4 phases with very specific management and exercises were described. - Following a structured, criteria-based pre- and post-op rehabilitation program that includes **extensive collaboration and communication between the surgeon and rehabilitation team**, patients undergoing hip arthroscopy can achieve excellent outcomes and return to full independent ADL as well as sport.
Kraeutler et al. (2017).	Return to running after arthroscopic hip surgery: Literature review and proposal of a physical therapy protocol	- Rehabilitation protocols for patients following hip arthroscopy frequently use a four-phase system in which **Phase I focuses on regaining hip ROM** and protection of surgically repaired tissues, and **Phase IV involves a pain-free RTS.** - Rehabilitation protocols vary in timing, in that some include a timeline with each phase taking a certain number of weeks, while others are based on goal achievement. - **There is an overall lack of published outcomes** based on patients adhering to various post-hip arthroscopy rehabilitation protocols.

Heerey et al. (2018)	Impairment-based rehabilitation following hip arthroscopy: Postoperative protocol for the HIP Arthroscopy international randomized controlled trial	Postoperative **rehabilitation is part of the treatment algorithm,** although there is a **lack of high-quality studies** on the efficacy of both surgery and postoperative rehabilitation programs. It is known that **impairments can be present up to 2 years after hip arthroscopy**, with individuals exhibiting reduced function and quality of life when compared to those of similar age, highlighting a need to improve postoperative care. Postoperative rehabilitation programs aim to improve hip function; however, the description of interventions as well as criteria for progression are lacking in the literature. **6 key components (manual therapy, hip muscle exercises, trunk exercises, functional exercises, cardiovascular training/load management, and education)**

NM: Neuromuscular; Post-op: Post-operative; ADL: Activities of Daily Living; ROM: Range of Motion

Table 22 gives a few examples of rehabilitation following hip arthroscopy. However, none are explicit with regard to comparing differences in rehabilitation protocols e.g. limitations in certain exercises, weight-bearing status, total duration of rehabilitation programmes etc. There is no high quality evidence that any one is more effective than another.

There have been a number of studies explaining a rehabilitation protocol post hip surgery. However, there is no definitive outcome to be used by clinicians. Discussion has centred around various topics e.g.

- Whether formal rehabilitation improves outcomes following hip arthroscopy as compared to an educational brochure (Bennel et al., 2014).
- The fact that return to running and impact sports were shorter for labral procedures and bony procedures and longer for cartilaginous and capsular procedures. Further there is marked variability in the post-operative weight-bearing practices of hip arthroscopy surgeons and should depend on the precise pathology (Rath et al., 2017).
- Science-based, patient-centred reasoning is integral to provide the highest quality of specific rehabilitative and preventative care for ice hockey athletes (Wolfinger and Davenport, 2016)

Guidelines and different protocols for post-operative rehabilitation were presented in a number of studies (Edelstein et al., 2012; Hegedus et al., 2013; Jayasekera et al., 2013; King et al., 2015;

Lovett and Kennedy, 2013; Malloy et al., 2013; Philippon et al., 2009; Pierce et al., 2013; Short et al., 2016; Spencer-Gardner et al., 2013; Tansey et al., 2015; Wahoff and Ryan, 2011).

All the protocols for post-operative surgery should not be considered a "cookbook" approach to rehabilitation, but rather guidelines that are used to achieve consistent outcomes. I personally believe that if one follows the basic rehabilitation exercises (as mentioned in this chapter), with communication with the relevant surgeon involved as to the precautions and stages of progress, the post-surgical rehabilitation should be fruitful. This has been alluded to in Chapter 7 – Surgery. From my experience, the most important factor is always to communicate with the surgeon to understand his/her requirements and to discuss the athlete's personal needs, goals and socio-economic structures.

Summary - Post-Operative Rehabilitation

The current literature of hip arthroscopy shows no specific protocol, as the risk factors and musculoskeletal factors will be different for everyone. Generally, rehabilitation guidelines following hip arthroscopy have been presented in the literature with common themes consisting of initial protection, restoration of lumbo-pelvic stability, neuromuscular re-education, and return to sport training. The restoration of normal gait without pain or compensation is imperative for the advancement of the rehabilitation process. I would argue for a rehabilitation protocol uniquely designed for the individual and return to sport progression advanced slowly to prevent overload and requiring constant monitoring. I propose that pre-screening and relevant exercise protocol prior to surgery may well prevent surgery in most cases.

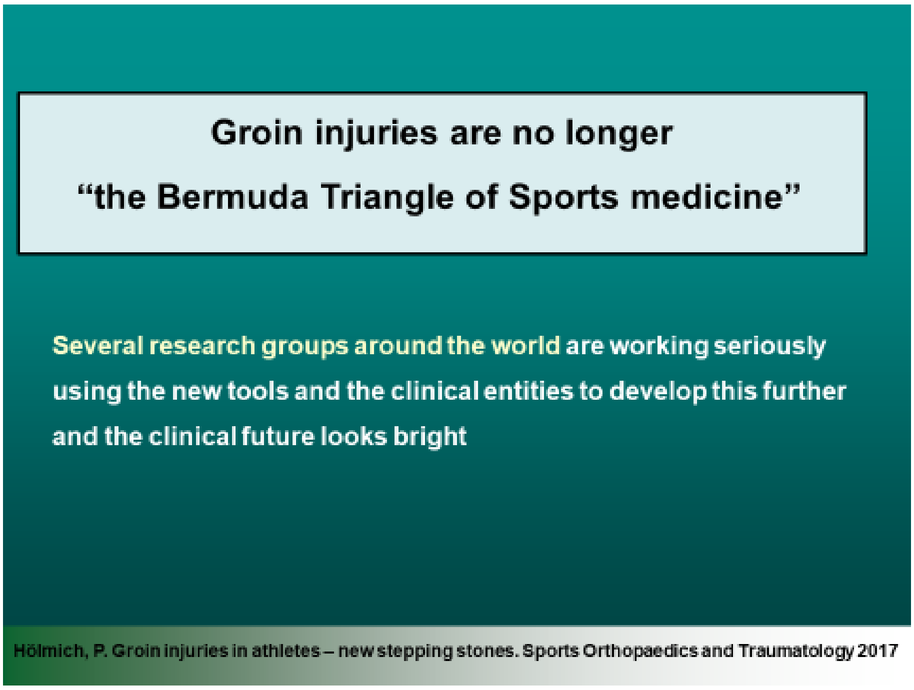
8o. Medico-Legal Ethics Issues

Slide 253

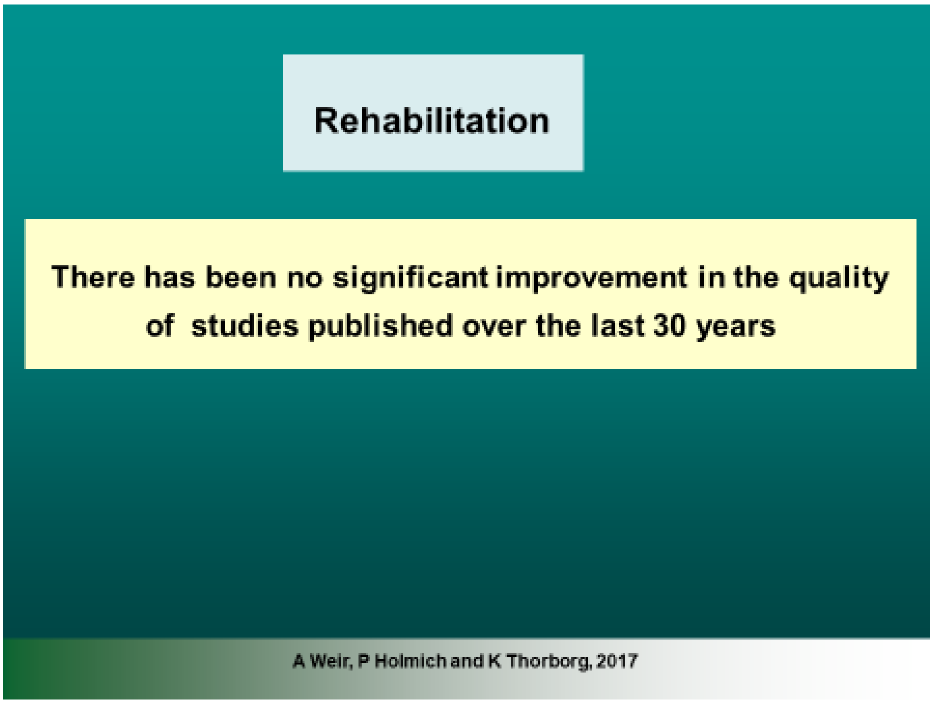
Part of the rehabilitation procedure is to make thorough notes at all times and have an auditable record of the injured player's rehabilitation process which is placed on a confidential database. Not only is this mandatory for medico-legal reasons, but ethically, it is the correct procedure for clinicians to follow (Slide 253).

Conclusion - Rehabilitation

Slide 250



Slide 251

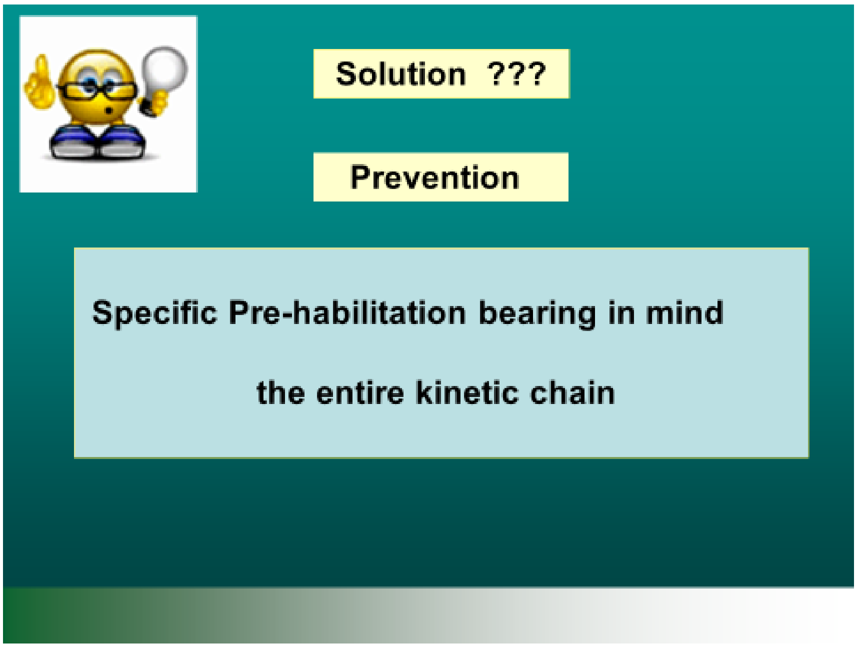


As shown by Holmich (2017) (Slide 250), it is now accepted that groin injuries are no longer considered to be the “Bermuda Triangle of Sports Medicine”. However, Weir et al. (2017) confirmed that there has been no significant improvement in the quality of studies published over the last 30 years (Slide 251). This was previously highlighted by Almeida et al. (2013) and Serner et al. (2015).

Basic guidelines for rehabilitation of the groin and hips are mandatory in order to optimise rehabilitation i.e. understanding anatomy and functional anatomy, assess any malfunction of the entire kinetic chain and off load the pubic joint. Further, there needs to be gradual progression based on functional and clinical markers which requires re-evaluation every 2 weeks. A suitable time frame is required for possible surgery and each athlete must be individualised.

Although there is evolving research to develop more structured management of groin and hip problems which requires ongoing analysis, experience and clinical reasoning with excellent knowledge of the anatomical implications for successful management is fundamental. I have definitely improved my management of groin and hip pain with increased knowledge (be-it from studies, discussions or conferences) over the past years whilst undergoing this PhD.

Slide 252



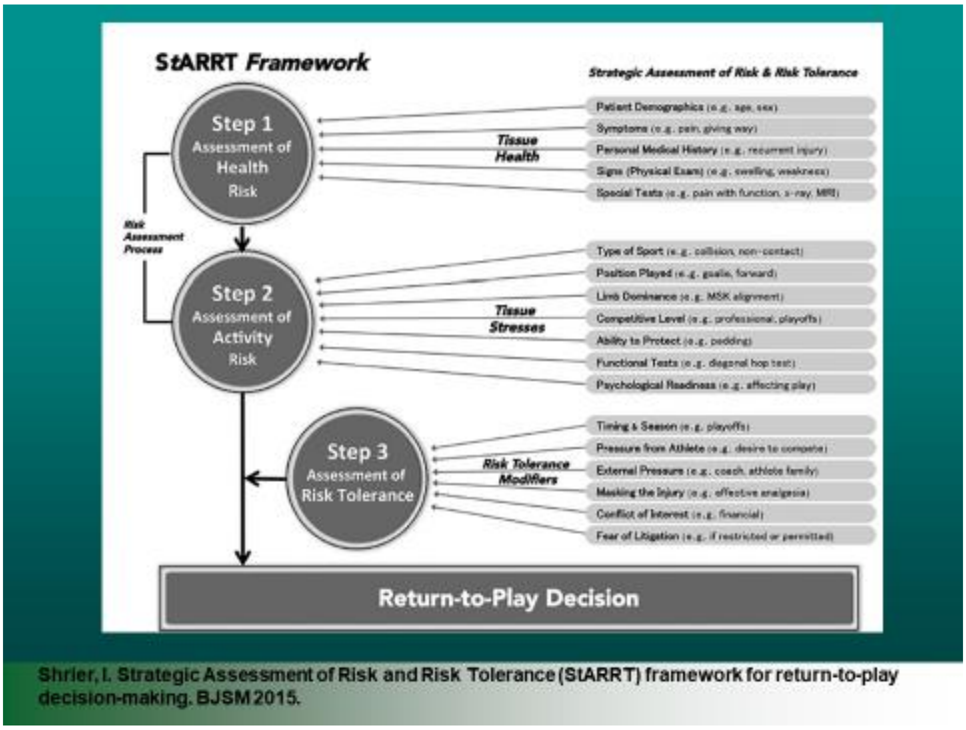
In spite of the lack of specific rehabilitation protocols, I still believe that so many of these groin and hip problems can be prevented in the first place (Slide 252).

Chapter 9: Return to Sports

9a Background

Rehabilitation and return to sport after sustaining a groin or hip injury is a significant and difficult consideration and has been a common feature of my presentations over these past years. Although a number of studies demonstrate return to sport after surgical procedures (Glaws et al., 2018; Rath et al., 2017; Rosinsky et al., 2019), there is a dearth of research regarding conservative management of rehabilitation and a return to sport protocol after a hip or groin injury (Arden et al., 2016). In particular, the objectivity (or lack of it) and the complexity of the numerous factors such as specific diagnosis, possible overlapping pathologies, degree of injury, psychological profile, the sport and level of participation increases the complexity of return to sport (Annear et al., 2019; Arden et al., 2016). Return to sport in practice is a constant learning process which is particularly refined by experience.

Slide 253

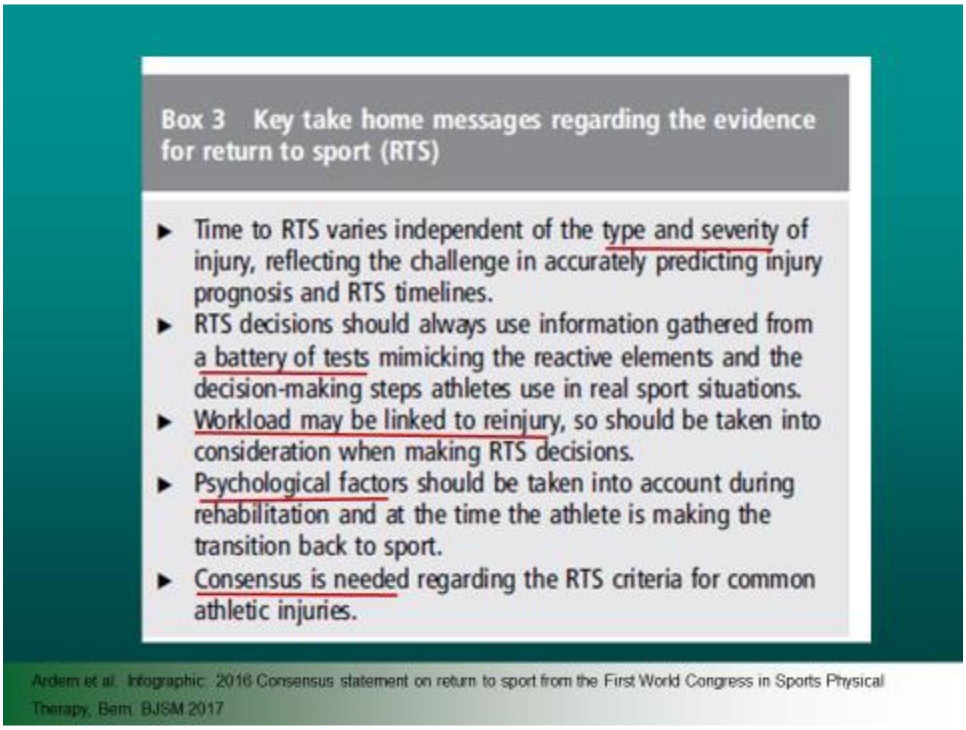


The StARRT Framework proposed by Shrier (2015) showed three steps in a return to sport framework. They felt that clinicians should combine information from a biological, psychological, and social standpoint. As Slide 253 shows, these factors include:

1. Health risk based on the athlete's specific injury (subjective and objective measures)
2. Activity risk of returning to sport (type of sport, competition level, etc.)
3. Risk tolerance (pressure, fear of re-injury, etc.)

This protocol was highlighted in the Consensus Statement on return to sport (Arden et al., 2016) and is currently noted in many presentations and also used in practice.

<u>Slide 254</u>



The consensus statement on return to sport was undertaken with 17 expert clinicians present (Arden et al., 2016) (Slide 254). This included a number of different pathologies. The consensus concluded that the key take-home messages regarding return to sport was
that one should combine information from a biological, psychological and social standpoint while considering the risks in order to assist decision-makers (clinicians, athletes, coaches or other stakeholders) to make optimal decisions. Integrating clinical expertise, research evidence and athlete preferences is important for return to sport decision-making. Unfortunately, return to sport criteria for many common injuries are not based on solid scientific evidence. These return to sport decisions should be shared among all stakeholders (except in the case of health risk to the athlete). In particular, they declared that return to sport was a continuum comprising three elements: return to participation, return to sport and return to performance and I value this basic advice which I use all the time.

Further, I have an art-document showing these 3 phases which I have put on the wall in the coach's office and explained the exact consequences of each one. I believe that educating, informing and discussing these basic details is of great assistance for the coach / clinician relationship and thus for the athlete.

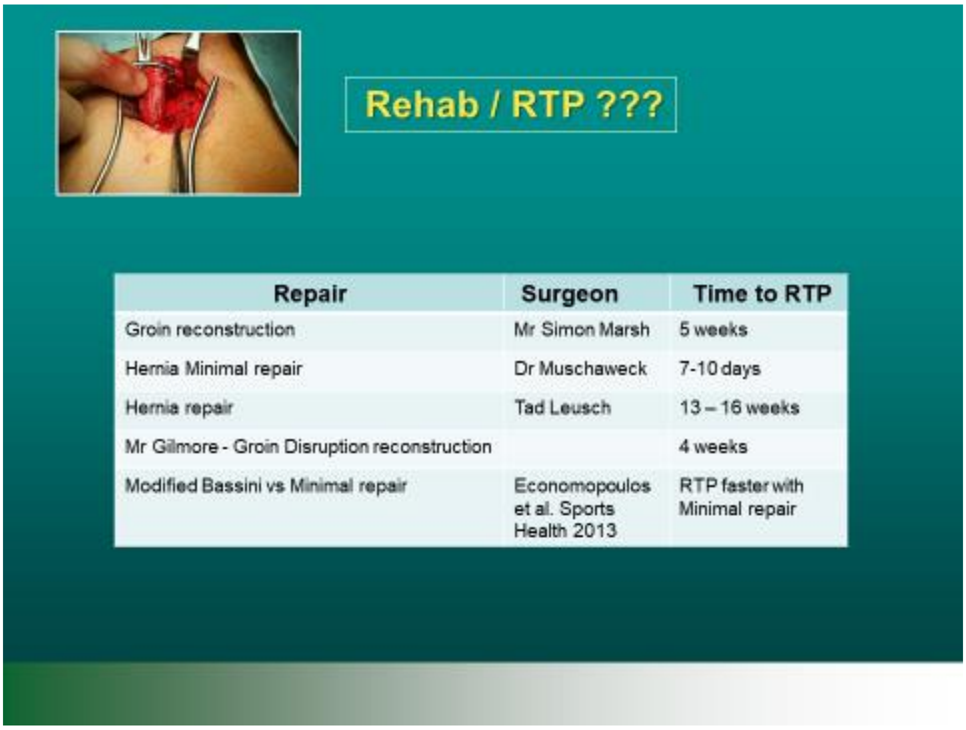
Another internationally recognised protocol is that of Robertson et al. (2017) who discussed the potentially useful traffic light system - Red, Amber, or Green Athlete Monitoring in Team Sport, where colour coding is used to indicate a given status of an athlete with respect to performance or training availability. However, despite relatively widespread use, there remains a lack of standardization with respect to how traffic-light systems are operationalized. What is most important, as suggested by the authors, is integration within multidisciplinary teams and the upskilling of staff and coaches in sport science. I have found these 2 recommendations to be of value in my practice.

Although studies have assessed the possible predictors for time to return to sport, there is currently no strong evidence that MRI can predict time to return to sport. The individual variation in time to return to sport and different return to sport definitions, as well as low methodological quality and the considerable risk of bias in the current literature might be an explanation for this. Clinical findings are more valuable for prediction of time to return to sport than MRI measures, but predicting time to return to sport is generally inaccurate for the individual athlete (Ardern et al., 2016). Serner et al. (2020) explained that the strongest predictors of a longer time to return to sport after acute adductor injury were palpation pain at the proximal adductor longus insertion, a palpable defect, and/or an injury at the bone-tendon junction on MRI. For athletes without any of these findings, even extensive clinical and MRI examination does not assist considerably in providing a more precise estimate of time to return to sport.

9b. Return to Sport Post Surgery

From my experience in Premier League Football and other elite sports, there is a large variation in return to sport after groin and hip surgery. The protocol is based on the specific surgeon and the specific surgical procedure taking place e.g. Muschaweck and 7 - 10 days to return to play, compared with Lloyd with 3 weeks return to play, with the players / Clubs wanting the former so as to get a speedy return to play.

Slide 269

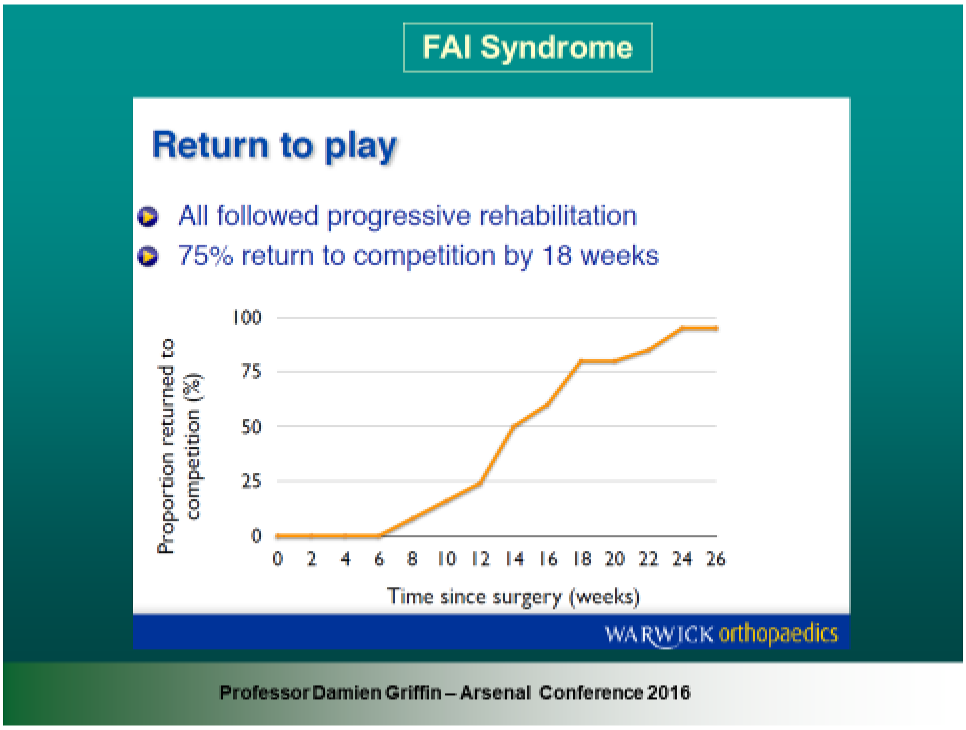


The issue of return to sport after groin and hip surgery has been somewhat contentious and variable over the past years (Slide 269).

Return to sport times after surgery for Long Standing Groin Pain were similar to return to sport times after non-surgical procedures, but for full adductor ruptures a faster return to sport was seen with a non-surgical approach compared with surgery (Ardern et al., 2016). They explained that return to sport rates were high (>85% returned to some form of sport) after hip and groin injury and surgery, but this was based on poor quality evidence. Further, after groin injury most athletes return to sport within 4 weeks but this must be considered against a high recurrence rate (15–25%). When re-injury occurred, or if adductor and abdominal injury coexisted, a longer absence from sport could be expected.

Casartelli et al. (2015) showed that most athletes return to sport after hip surgery for the treatment of symptomatic FAI, with 87% of patients returning to sport and 82% returning to previous level of competition. Amongst other issues, the level of competition, time of evaluation after hip surgery and presence of articular cartilage lesions at the time of surgery may influence return to sport. Menge et al. (2017) stipulated that although 87% of the arthroscopic procedures allowed professional football players with "FAI" to return to sport, linemen were less likely to return compared with other positions, and the presence of micro-fracture did not significantly affect the return to play rate. Another study showed that 94% of athletes returned to running after hip arthroscopy for treatment of symptomatic FAI and capsular plication, although patients with a higher bone marrow oedema and/or longer pre-operative lull may have a longer recovery time (Levy et al., 2017).

Slide 270



As shown in Slide 270, Damien Griffin shared his surgical experiences for FAIS (Arsenal Conference, London, United Kingdom. 2016) and it was interesting to note the 18-week rehabilitation period before return to sport. The Premier League football players generally have this surgery during the off-season in order to prepare for return to sport at the beginning of the season.

Studies on return to sport has revolved around pathologies such as ACL reconstruction, none to date have used qualitative, semi-structured patient interviews on patients with hip labral tears. Factors affecting return to sport include self-motivation, aging, pain, peer encouragement, social support and adapting to physical limitations after arthroscopic hip surgery for FAI. Again the importance of psychological input for a coping mechanism may aid in a patient's postoperative recovery and allow for a speedier return to sport (Tjong et al., 2016).

In order to be effective, clinicians may follow general guidelines while individualizing the progression to align with the patient's goals and expectations. The basis is that the clinician requires effective communication with the surgeon regarding the management and progression of the rehabilitation and the surgeon's expected return to sport protocol (Domb et al., 2016). Other studies that discuss return to sport post arthroscopic surgery include Choi et al., 2016; Degen et al., 2016; Elattar et al., 2016; Weber et al., 2017. Their conclusion was that generally there was a high return to sport post-surgery. However, no protocols for return to sport were demonstrated. Thus it is difficult to have a "one-size-fits-all" strategy regarding rehabilitation and return to sport for post-operative hip and groin problems. There is definitely a need for future studies with higher levels of evidence to describe and evaluate return to sport protocols after hip surgery.

9c. Return to Sport - Tests

Tests have been comprehensively discussed in Chapter 5 – Groin and Hip Assessment. In terms of return to sport, it is necessary that the clinician takes cognisance of the importance of all proposed return to sport tests even if they are not sacrosanct. Further, they should be related to the specific sport (and position) of the athlete.

Table 23: Return to Sport (RTS) – Tests

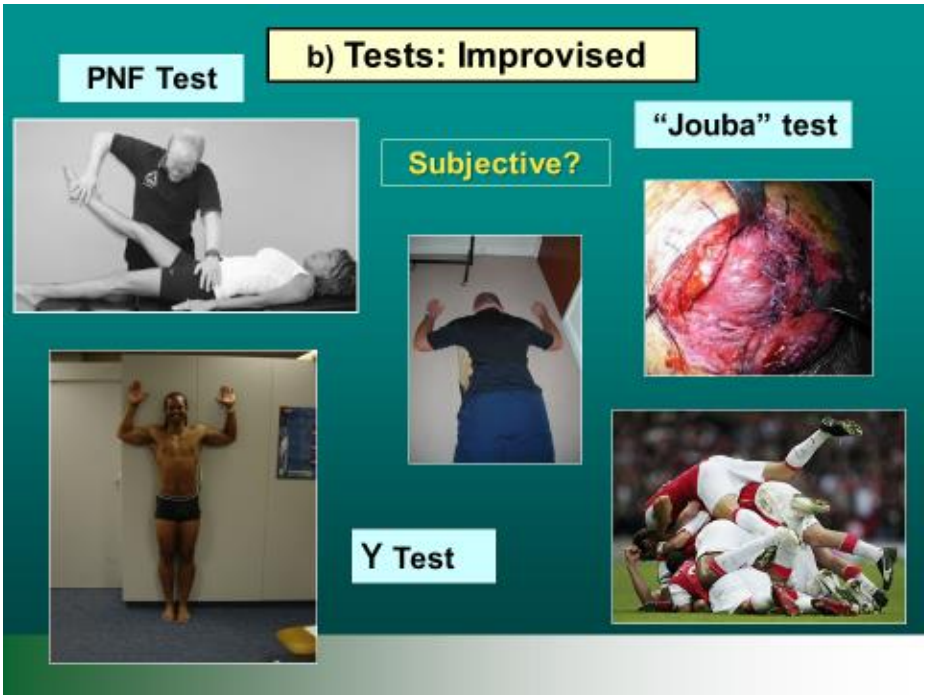
Author	Test	Outcome
Kivlan et al. (2013)	The **medial and a triple hop test** performance amongst dancers with symptomatic FAI	Deemed **reliable and valid** when determining **RTS** after hip injuries.
Hegedus and Cook, (2015)	**Physical performance tests (PPT):** re they evidence-based, rough guess or charade?	Self-report measures tend to capture the athlete's mind set, as it relates to function, whereas PPT (single leg hop test and its variations - triple, crossover, and timed 6m hop) are less influenced by things such as emotion or mood. **Practitioners need to use both self-report measures and PPT.**
Snyder J. (2016).	**Single-leg Stance; Deep Squat; SLS, SEBT/Y-Balance Test.**	These tests have **appropriate validity and reliability. They aid in measuring RTS, but cannot be used exclusively for RTS**

Kivlan et al. (2016).	Help clinicians to **measure progress** to RTS as well as assist in screening of dancers with complaints of hip pain.	Dancers had **less strength of the hip extensors and performed worse during medial and lateral hop triple tests** compared to healthy dancers. These findings may be used as a **guide** for **progressing RTS.**
Johansson and Karlsson, (2016).	Validity of the **SEBT** in individuals with FAI.	The results showed that the **SEBT demonstrated adequate divergent validity and may be a useful tool for RTS.**

SLS: Single leg Squat; SEBT: Star Excursion Balance Test; PPT: Physical Performance Tests

As Table 23 demonstrates, there are very few validated studies regarding return to sport criteria.

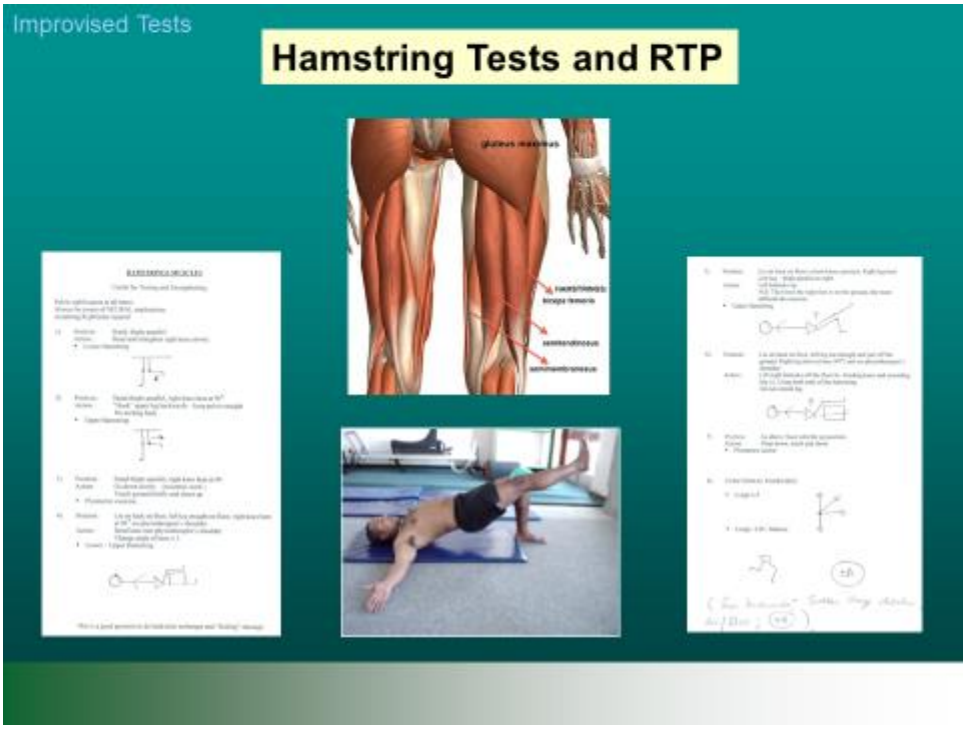
Slide 267



In the absence of sound concise evidence as to return to sport criteria, it may be advisable that the clinician devises a practical and useful tool for return to sport by performing tests which may not have been done before and may have no scientific backing. The validation and reliability of these tests used clinically could then become a focus of some of the return to sport research. A few cases to demonstrate this in my professional career, include the PNF test which was discussed previously. Just to re-iterate, apart from identifying potential problems, this was most helpful to judge an athletes return to sport, even though it is subjective. This was used for groin and hip problems (adductor specific), as well as for other injures where the lower extremity biomechanical strength needed to be assessed (1st picture) (Slide 267).

Further, the commonly used "Y test", was used by an orthopaedic surgeon in his decision-making for one of the Super 14 rugby players to return to sport after a total rotator cuff repair of his shoulder. However, in the first game on his return, the rotator cuff re-tore. This was due to the fact that when he lay in the prone position on the rugby field and the opposition players were on top of him, his gleno-humeral range of motion was not good enough to sustain that pressure. Thereafter, I devised the test for return to sport in that particular sport, which was a specific prone lying test (Slide 271). This is subsequently utilised by a number of the orthopaedic surgeons and is called the “Jouba test” with the player’s permission. It would be most useful if these “new” and innovative strategies could be scientifically evaluated.

Slide 268



In 2002, I developed another battery of tests for hamstring injuries and return to sport, whilst with the Stormers Rugby team (Slide 268). This was due to the fact that there was no evidence internationally regarding this dilemma. It was one pathology that I was unable to coherently and methodically explain to the coach regarding return to play. Thus this seven- tiered return to sport flowchart (in conjunction with functional and field tests) was developed and was well utilised by all clinicians in future years. Currently a PhD student at Kent University is undertaking a study to demonstrate the validity of this protocol.

Although these examples are not all related to the hip and groin, the point is that clinicians should attempt to create some test that may help in future return to sport protocols. This is possible by using clinical reasoning and experience.

9d. Psychological Factors

Medical practitioners, working with injured players are often focused on physical aspects (e.g. tissue healing) and other objective physical markers such as strength, power and function when contributing to the shared return to sport decision-making process. Being fully functional and physically ready to return to training and competition is important. However, being mentally ready to return is critical for return to sport and full performance. From my experience this is a major factor and makes the objective return to sport onerous.

Of note throughout these return to sport phases, is the clinician's ability to create an autonomy-supportive environment, and particularly to ensure there is no conflict between the expectations of the coach and the returning player (Carson and Polman, 2017).

Slide 261

Psychology Studies

Journal	Article	Author	Comments
Clin J Sport Med. 2005.	**Returning to play: the mind does matter.**	Bauman J,	
JR Soc Health. 2007	Psychological responses to injury in competitive sport: a critical review.	Walker et al,	Inter-relationships between emotional responses, behavioural responses, cognitive appraisals and recovery outcomes **NOT SIMPLE**
J of Athletic training 2009	Development and Preliminary Validation of the Injury-Psychological Readiness to Return to Sport (I-PRRS) Scale	Glazer D	Aim: To develop a scale that measures the psychological readiness of injured athletes to RTSparticipation and to provide preliminary evidence of reliability and validity for the scale.
Scand J Med Sci Sports. 201	Psychology and socioculture affect injury risk, response, and recovery in high-intensity athletes: a	Wiese-Bjornstal	Continued efforts in psychological research and professional practice are needed to protect athlete … e toward … evity.
J S… 20…			
Phys Ther. 2011	Longitudinal changes in psychosocial factors and their association with knee pain and function after anterior cruciate ligament reconstruction.	Chimielewski et al	
BJSM 2011	Return to sport following ACL reconstruction surgery: a systematic review and meta-analysis of the state of play.	Ardern et al	Other factors such as psychological factors may be contributing to return-to-sport outcomes.
BJSM 2012	A systematic review of the psychological factors associated with returning to sport following injury.	Arden et al	
Sca J Med Sc Sports. 2013	Psychosocial factors influencing the recovery of athletes with anterior cruciate ligament injury: A systematic review.	Te Wierike et al	

Psychological readiness to RTS is major factor.

The psychological profile of the athlete for return to sport is a major factor and has been published in a few studies, although not necessarily involved with the hip or groin (Arden et al., 2014; Podlog et al., 2014; Wadey et al., 2014) (Slide 261). With my involvement in so many different sports and with male and female athletes, anecdotally, I believe that the psychological attitude of the player / athlete returning to the sports is often underestimated. My role as physiotherapist over the years has encompassed psychological input, as in many cases the athlete's confidence has diminished especially after a long term injury. This factor was revealed to me at a birthday celebration in 2016, where the Stormers rugby coach gave a thank you talk and surprised me by the fact that when he spoke of me, he never once mentioned my physiotherapy skills. He only explained the value of my psychological and positive input over 5 years. It was an eye opener for me, as it was not done consciously. I thus feel that physiotherapists may benefit greatly from psychological courses in their undergraduate training.

Slide 262

Slide 262 portrays the individual characters of the players as shown on the photographs and discussed in my presentations (with the player's consent) to demonstrate the individual psychological make-up and thus managing each athlete accordingly for a return to play protocol.

Slide 263

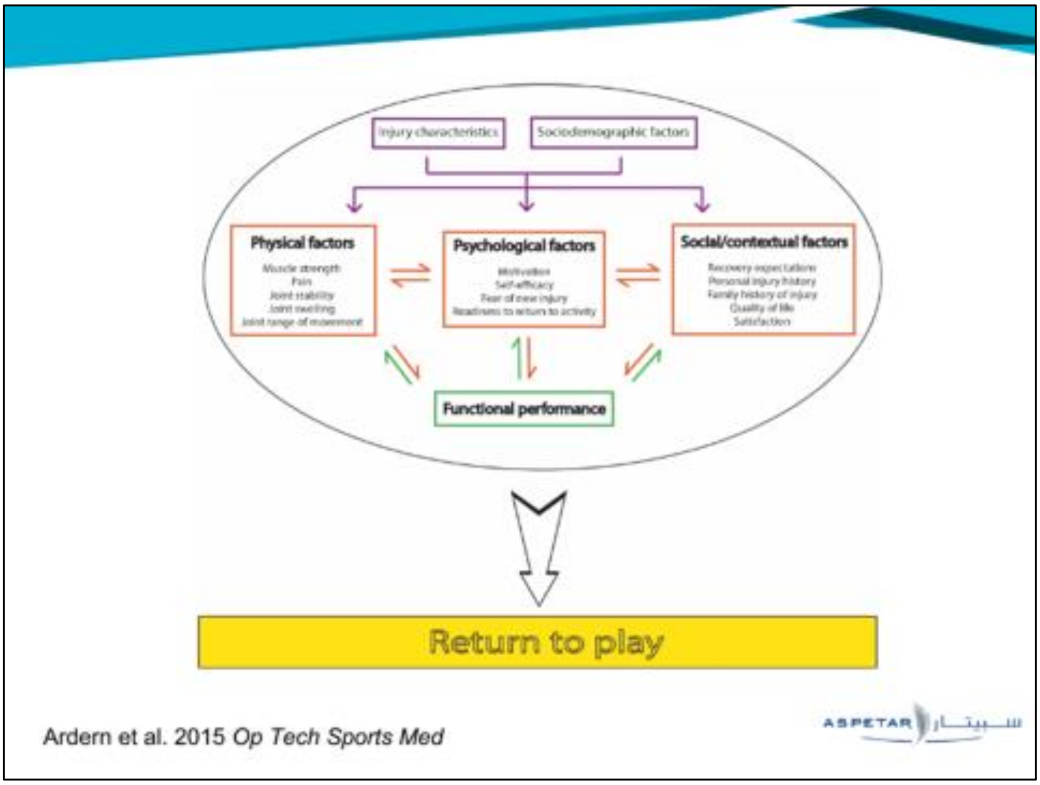
Anxiety, deprivation and apprehension are major factors which need assessing (Slide 263).

Slide 264

The repercussions of sport-related anxiety were demonstrated by Ford et al. (2017) (Slide 264). I observe these insecurities and the resultant impact amongst my sports players fairly frequently and thus I concur with their study, which suggested that re-injury anxiety can negatively impact athletic performance after returning from injury. An athlete may be hesitant to give 100% due to lack of confidence in the injured body part, resulting in increased worry and tension. In addition, they found that anxieties related to the inability and/or uncertainty to return to pre-injury level of performance influenced a successful return to play process. This was reaffirmed by Hsu et al., 2017.

Thus an individualised, structured return to play algorithm / flow chart undertaken by the clinician is essential and requires interaction and consequential confidence of the athlete. Moreover, lack of athletic identity, feelings of isolation, and pressures to return to sport when the athletes themselves do not feel ready to return, are also typical emotional responses during the return to play phase, and they are likely to increase anxiety if not addressed (Ford et al., 2017). This was highlighted by O'Keeffe et al. (2019) who strongly recommended psychological rehabilitation for managing post-injury psychological distress in male adolescent Gaelic footballers. My feeling is that the clinician should be aware of these anxieties and not “exclude” the player from the team environment when rehabilitating him / her (as discussed previously).

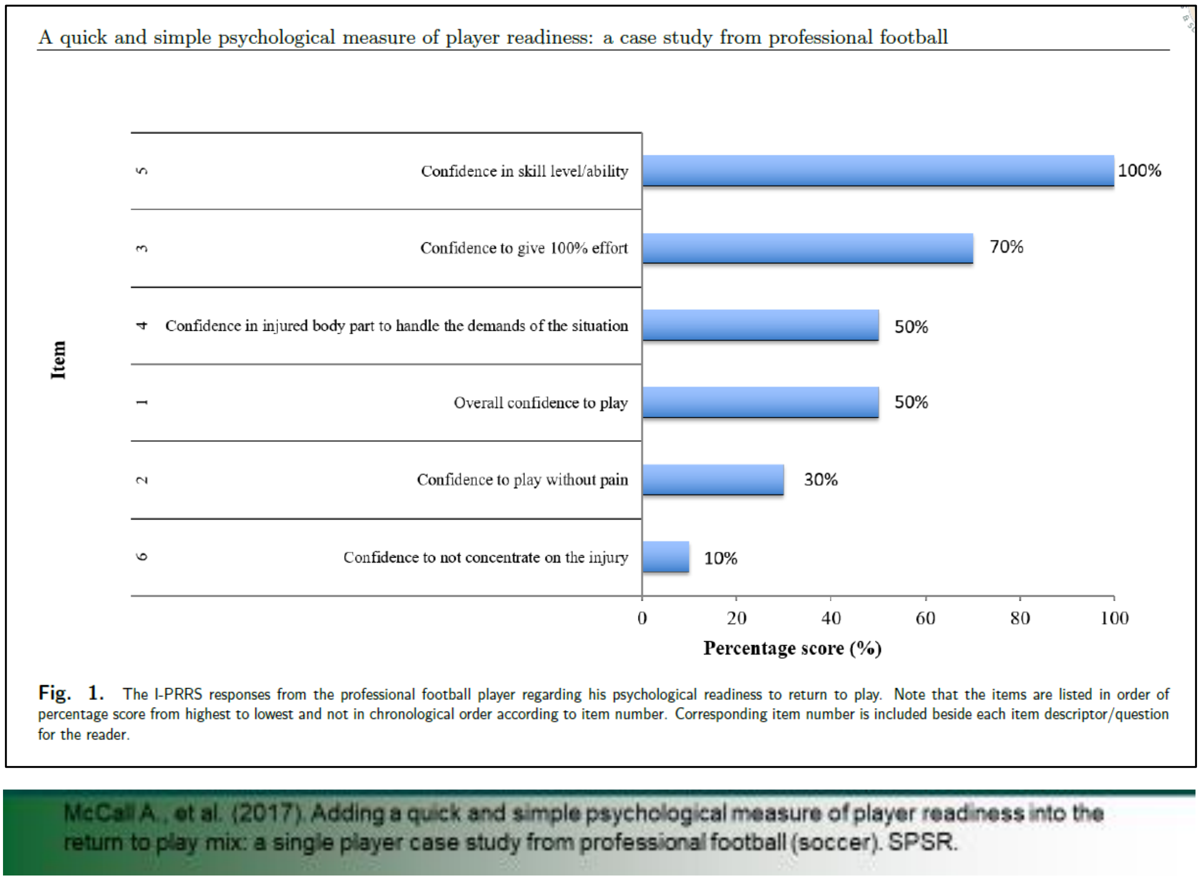
Slide 265



Arden re-emphasized the athlete’s psychological input regarding return to play, as well as the social contextual factors to be considered (Arsenal Football Club, Sports and Exercise Medicine Conference, London, United Kingdom. 2016). (Slide 265).

To appropriately recognize and treat sport-related anxiety, clinicians must ensure that they recognise, sympathise and provide each of the athletes with specific and practitioner competent care and refer to other professionals when necessary. This was the case with one of my South African / Super 14 rugby players who presented with elevated anxiety following an ACL injury, with subsequent surgery and lengthy rehabilitation. I sent him to a psychologist (who was also a fitness trainer with the South African Rugby team), outside of the team environment. This was of great benefit to him and facilitated a more confident return to play. Further, I did not disclose this referral to anyone (bar the Doctor, with the player's permission). This became a poignant discussion, particularly by the coach, at the end of the season who felt he should have been informed. However, ethically, I felt it was the correct decision, as it was in the player's and the team's best interest.

Slide 266

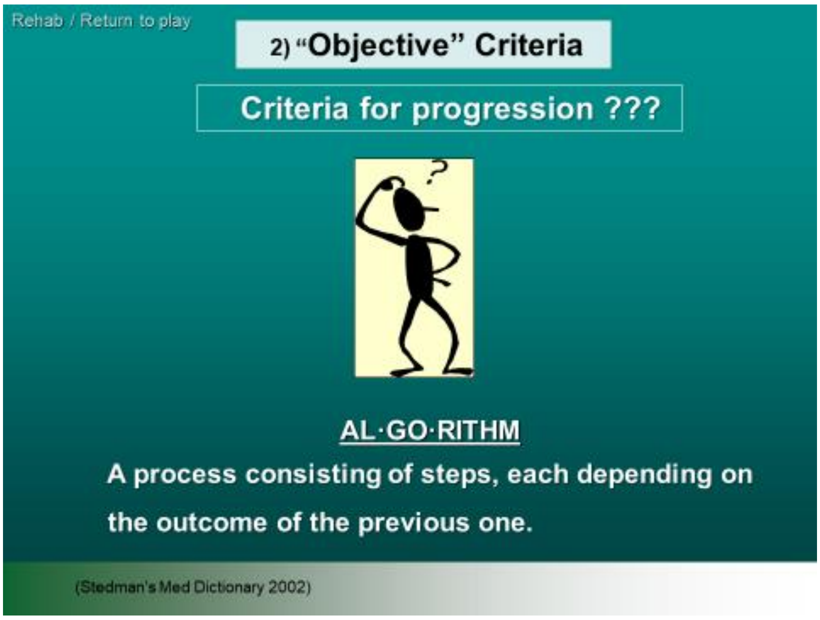


McCall et al. (2017) showed a possible solution to obtaining some measure of player's psychological readiness to return to play (Slide 266). This injury-psychological return to sport scale consists of 6 questions relating to the athlete's confidence in general, and specifically concerning their injury. The authors suggested that this useful tool may add a measure of psychological readiness to return to play, in conjunction with the plethora of physical measures used.

Although physiotherapists acknowledge the value of implementing psychological strategies in their current practice, limited knowledge and training regarding psychological techniques at undergraduate level, stigma towards receiving psychological care by athletes, and a lack of ongoing professional development opportunities specific to sports psychology, appear to impact the integration of psychological strategies in current practice (Annear et al., 2019).
I believe that there is an urgent need for targeted psychology education for undergraduate curriculums, as well as post-graduate training opportunities for sports physiotherapists for better integration of such strategies in clinical practice.

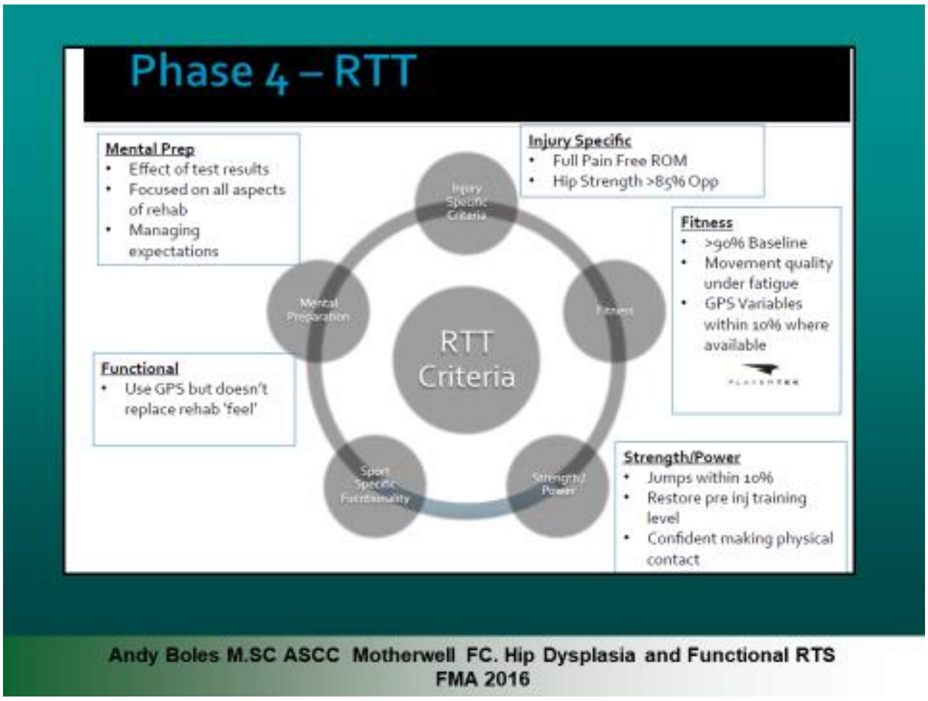
9e. Return to Sport - Progression

Slide 271



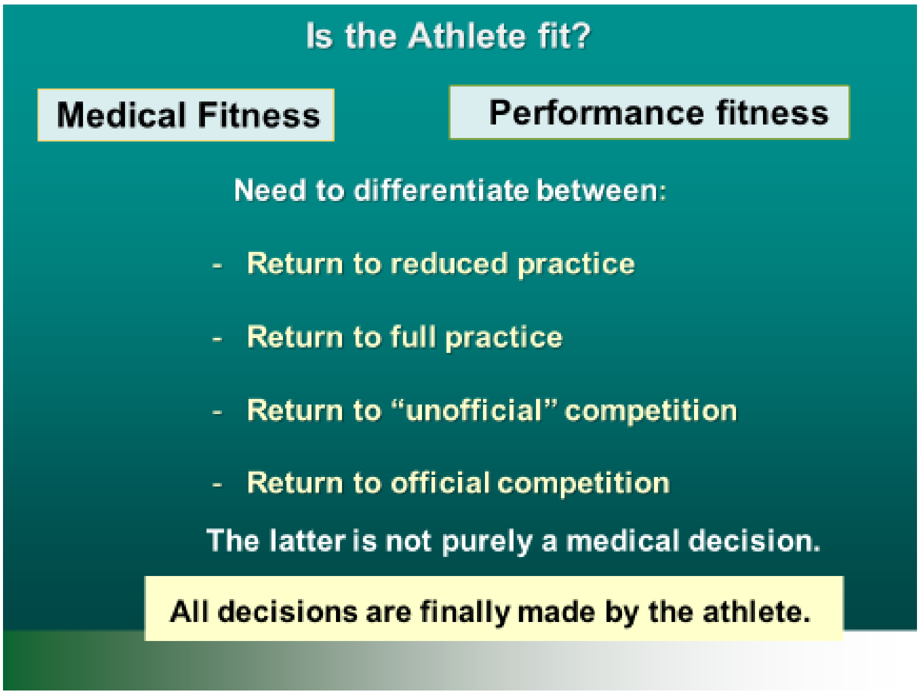
Thus, although it is difficult to have objective criteria for return to play (due to many variables, including the previously discussed psychological make-up), it would be of great benefit if the clinician has in-depth notes and clear, transparent criteria for progression of the rehabilitation and the final return to return to training, play and full performance (Slide 271).

Slide 272



As shown on Slide 272, (Football Medical Association Conference, Midlands, England, UK), Andy Boles gave an insightful, comprehensive reasoning for return to training protocols.

Slide 273



One should bear in mind that there are two basic elements for return to sport i.e. return to medical fitness and return to performance fitness (Slide 273) and the clinician can clearly mark the difference of return to training and return to sport and ultimately, full participation. As has been stated previously, it is thus imperative that there is strong collaboration between the medical team, the fitness trainer, the coach and the player for this stage of the return to sport protocol. That is not always an easy undertaking. I believe in communication and mutual decision-making and have found that so much depends on the attitude of the coach, as confirmed by Whatman et al. (2018). Sometimes I have been fortunate with a collaborative coach, but not always. From my perspective it is imperative that the clinician never bows to the demands of the coach if the injured athlete may be disadvantaged. Interestingly, having been physiotherapist for most of the national and provincial teams, I was told recently, that all the coaches trusted me as I never would bend to their demands. That is not easy, but an ethical obligation.

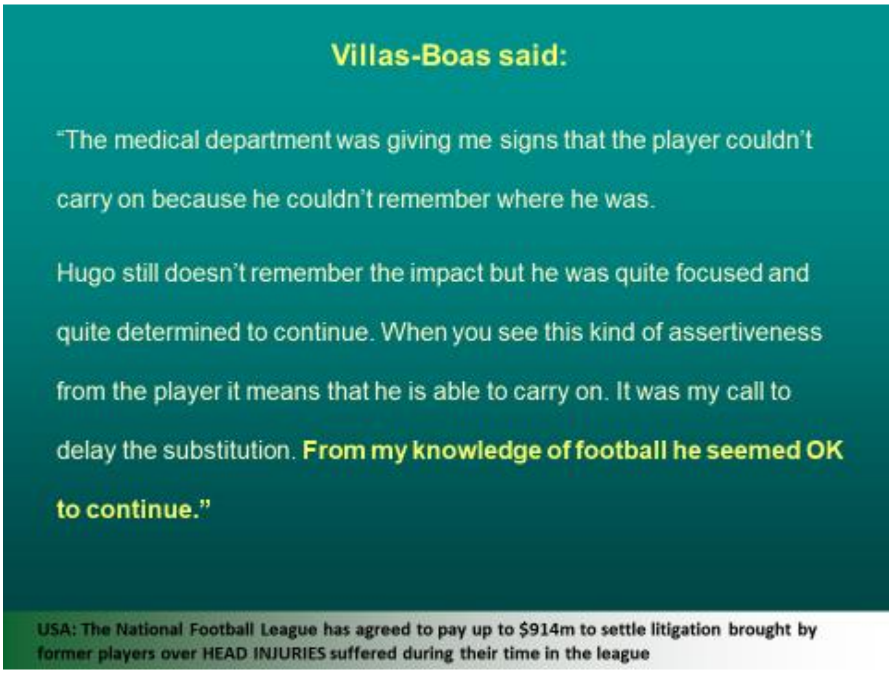
Many presentations have been given at different venues over the past years as to the return to sport criteria. However, it is difficult to give concise advice regarding hip and groin pathologies and return to sport.

9f. Decision making

The return to sport decision is a case of risk management, and athletes may continue to train or compete, despite being ill or injured. The quandary then is who makes the final decision regarding return to sport? Return to play decisions are complex, specific to the athlete and type of sport, and often influenced by factors such as pressure to return for a major event. There may be a difference with regards to return to play safety, for instance, if there is an athlete with a minor hamstring strain approaching the finals of a major championship or someone with concussion. In the first instance, the final return to sport decision-maker might be the athlete. The clinician would then require the athlete to sign a waiver. In the second instance (concussion), the healthcare professional should be the final return to sport decision-maker if the athlete’s decision-making capacity is compromised. Essentially, decisions regarding the immediate medical management (including return to play) of an ill or injured player on the field of play should be made by a healthcare professional (Dijkstra et al., 2016). The coach or manager should have no say as to whether the medical team should attend the athlete on the field or give an immediate player assessment.

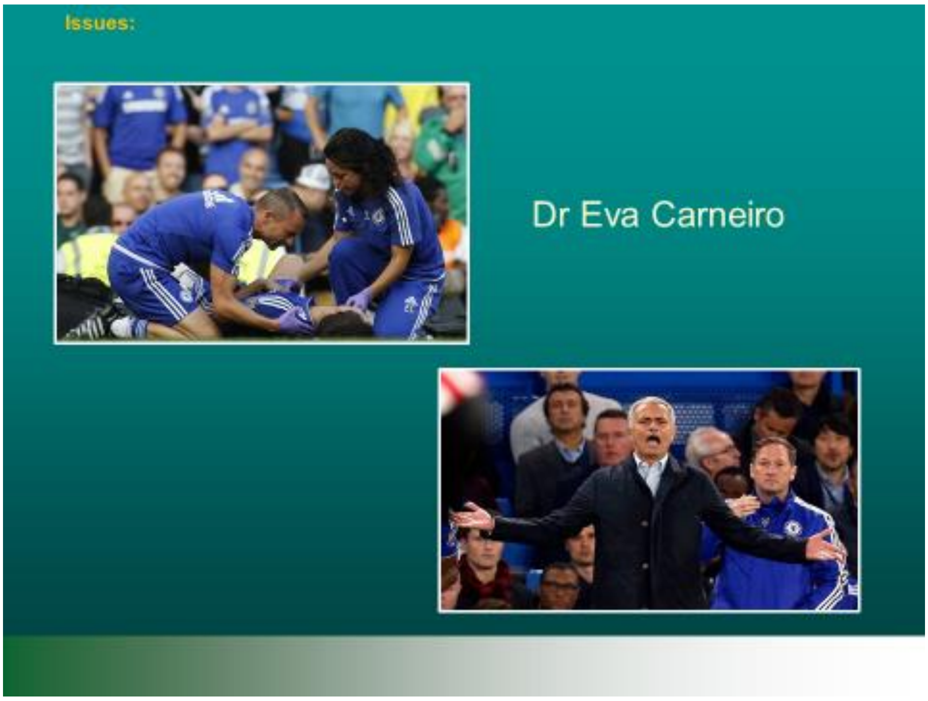
Slide 255

Slide 256



This was the case in 2013, when a football player from Tottenham Hotspurs, Hugo Lloris was concussed during a match against Everton football club. The incident caused an outrage nationally and internationally due to the manager's demands that the player continues playing and the over ruling of the medical doctor's instructions (Slides 255 and Slide 256).

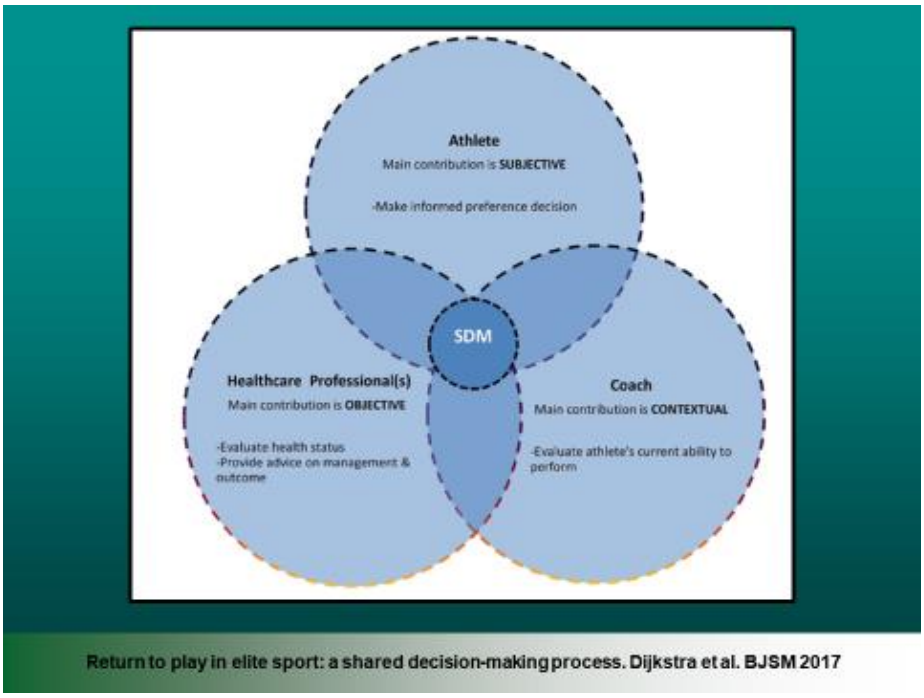
Slide 257



Similarly, in the case of Chelsea Football Club and the manager, Jose Mourinho, who caused a furore when he lambasted his Doctor and physiotherapist for running on the field when someone was injured (Slide 257). Although these examples are not related to groin and hip injuries, the same principle applies no matter what the injury.

The culpability of the clinician who makes the final decision was succinctly explained by Matheson et al. (2011). They declared that return to sport is a fertile field for research and requires a focus on the team physician's appropriate role in return to play decision-making, particularly considering the factors identified in decision modification.

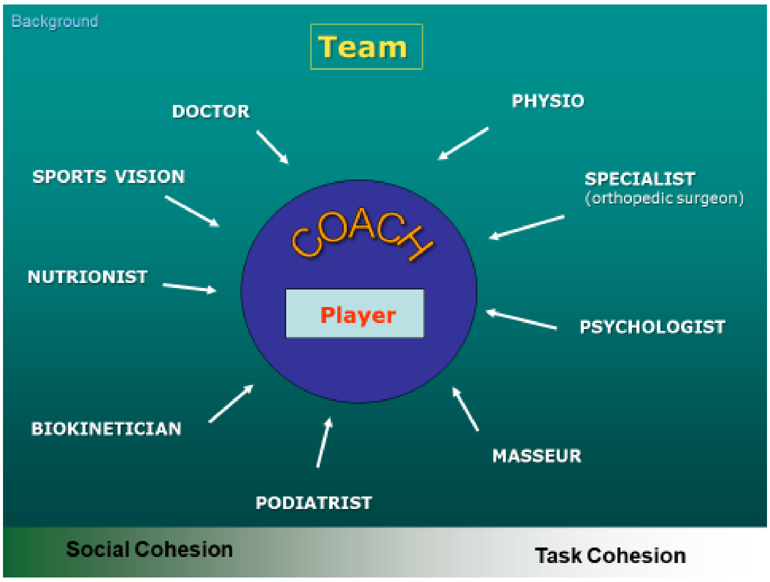
Slide 258



In an editorial, Djikstra et al. (2017), discussed the shared decision-making protocol (Slide 258). They state that the size of the contributing circles to the shared decision-making processes are influenced by different factors, including health status, participation risk and other decision modifiers. The position of the shared decision-making circle might therefore vary. In terms of groin and hip pathologies, as this is a difficult topic and particularly with regard to return to sport, the ideal is to have the healthcare practitioner as the main decision maker with input from all other parties acknowledged.

One of the comments made by the International Consensus team (Arden et al., 2016), was that the composition of and roles within the decision-making team should be determined as early as possible. This interaction is vital and an understanding of these management dynamics and the consequential outcome is crucial for an ethical, evidence based, clinical reasoning and decision. From my experience, this early discussion of different roles is not always practiced in sports and would be of great benefit.

Slide 259



Further, it was suggested in the Consensus Statement that members of the return to sport decision-making team should be prepared to regularly share information among all relevant stakeholders. Having been very practically involved in this decision-making for many years, I do not fully agree with this comment. There are a number of medico-legal and ethical issues involved. In meetings usually held once a week, there are often a number of medical personnel present who discuss all issues and then thereafter feed back to the coach/manager and the player (Slide 259). My question and concern is - Who should attend those meetings?

In elite sport, very often the financial stake holders require/demand information of an injured player from a medical clinician. This becomes complex. However, I feel that it is mandatory that they are not informed in detail and only when appropriate. This is an ethical, as well as a medico-legal matter and I have seen over the years, medical personnel explain the injury to financial or administrative staff who feel that they "own" the player and demand medical information. I believe that no job is worth the compromise of acting unethically and have experienced that whilst with the Super 14 rugby team whereby I once tried to resign rather than act unethically on behalf of my athletes.

This debate regarding divulging information to all stakeholders is ongoing and is a most pertinent point of discussion in my presentations on "Medico-Legal Ethical Issues in Sports Medicine."

Slide 260

From my work in all levels of sports, I reinforce the fact that interaction and working together with good communication and respect, is critical for the management of any athlete. The left picture on Slide 260 above, demonstrates the interaction between the masseur, the biokinetician and the physiotherapist (myself) when running on the field. Minimal discussion took place, as one immediately proceeded to work on the relevant area as required. Similarly, the picture on the right shows the passion and commitment shown by the same three members of the medical team when the penalty kick failed to go over the poles and resulted in team's loss in the finals for the annual tournament. This does have impact on the athlete's perception of the medical team and thus ensuing trust and respect.

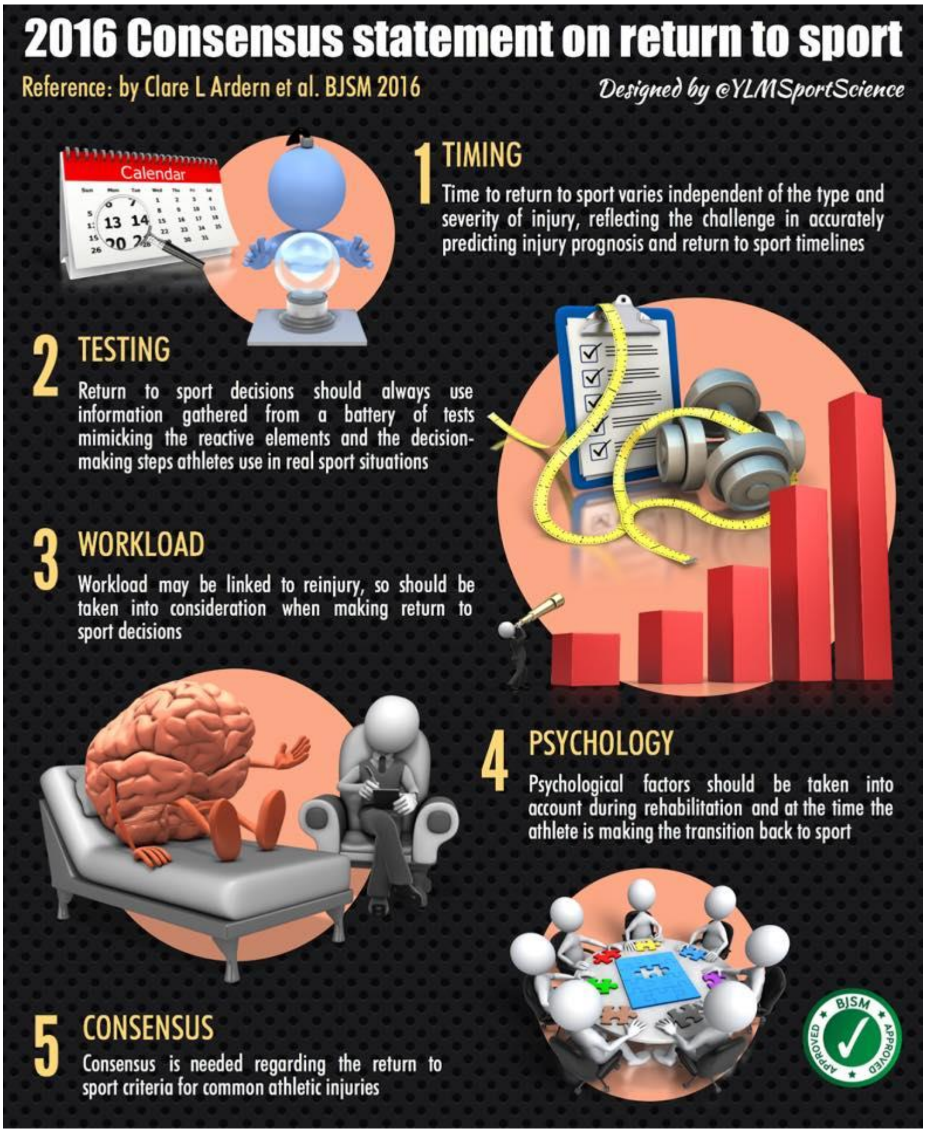
9g. Return to Sport - Medico-Legal Ethics

The topic of medico-legal ethics could be a thesis in itself and has been mentioned previously. Thus I only briefly would like to emphasise this fact regarding return to sport. Very specific and transparent notes are required to clearly demonstrate the return to sport strategy with communication and decision-making amongst all relevant medical personnel. Further, if a player wants to return to play against the wishes of the medical team and insists on doing so, he/she should sign a waiver of consent. In my career, I realise that I was negligent in this respect.

There is little or no evidence on this topic and it is so often not even on the agenda at conferences or in any discussions. I am passionate about sharing my experiences in this regard with many Medico-Legal Ethical presentations which I undertake nationally and internationally.

Conclusion – Return to Sport

Slide 274

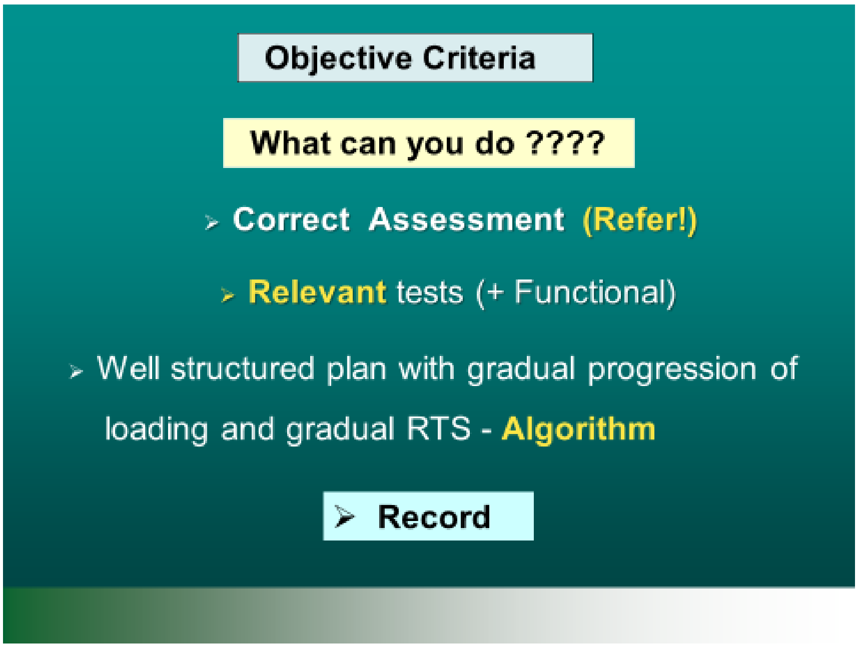


The 2016 Consensus statement on return to sport is most succinctly described and is a most helpful guidance for clinicians (Arden et al., 2016) (Slide 274).

While there is some evidence with regards to rehabilitation of the hip and groin, there is a dearth of knowledge and guidelines with regards to return to sport, whether following conservative management or surgery. As there is a limited number of clinical and functional tests that can help inform player readiness for return to play, clinicians may design their own return to sport battery of tests and algorithm for individual players specific to their hip or groin pathology, sport, position, or level of sports participation.

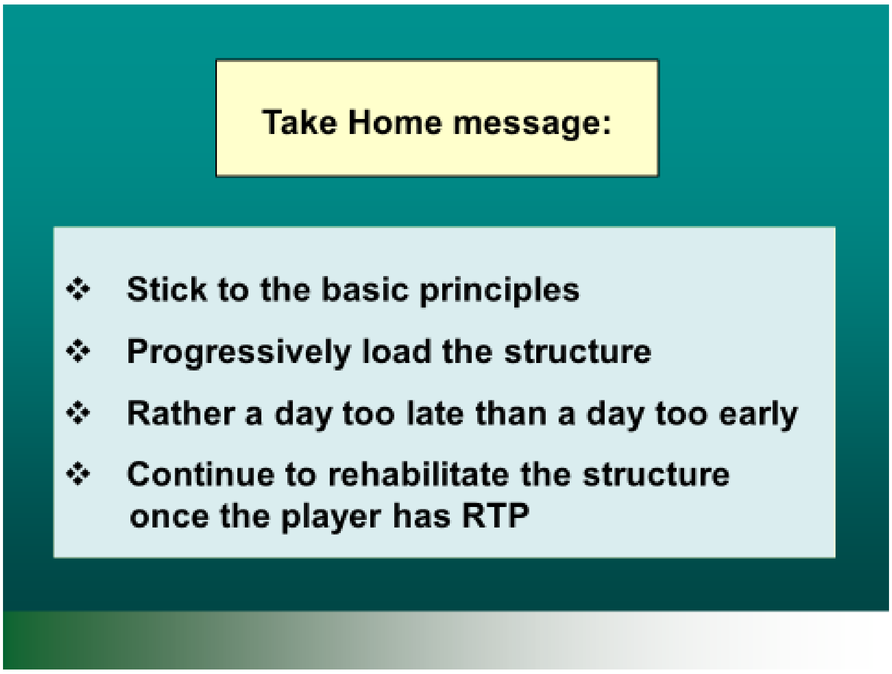
Significantly, after re-injury, as a medical team one tries to understand why the re-injury occurred, so that if (and when) faced with a similar set of recognisable circumstances again, one can improve the evaluation of risk and ultimately have more confidence in one's final recommendation to the manager/coach and player (McCall et al., 2017). I constantly analyse and note the return to play factors for all my athletes. Nonetheless, it is not fixed and requires constant assessment and relevant adaptations.

Slide 275



Until such time as the clinician has concise guidelines, I would suggest that he/she designs his/her own protocol with clear, clinical reasoning and very specific notes to demonstrate a concise and logical algorithm for return to training and full participation (Slide 275). Above all, the long term interest of the athlete requires consideration. Effective communication is essential to achieve trust among the key people involved, and ultimately, the quality of the return to sport decision.

Slide 276



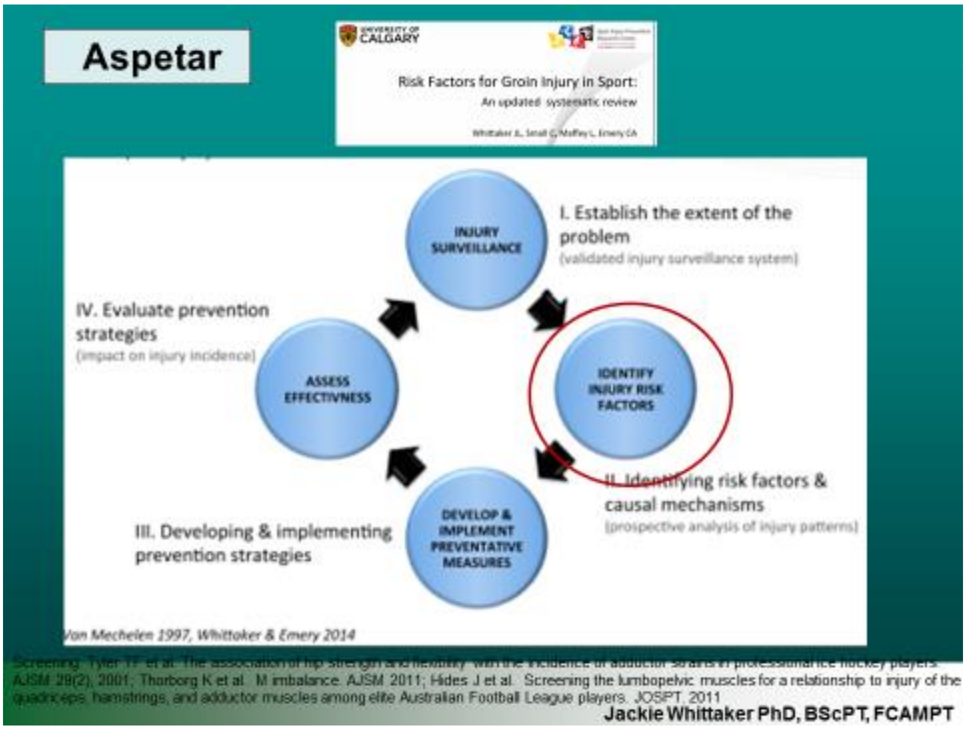
Thus as shown on Slide 276, the take home message is very logical. I would suggest that most pathologies and most definitely with groin and hip problems, the player / athlete continues with the rehabilitation protocol throughout the season after return to sport.

Chapter 10: Risk Factors for Hip and Groin Injuries

10a. Introduction

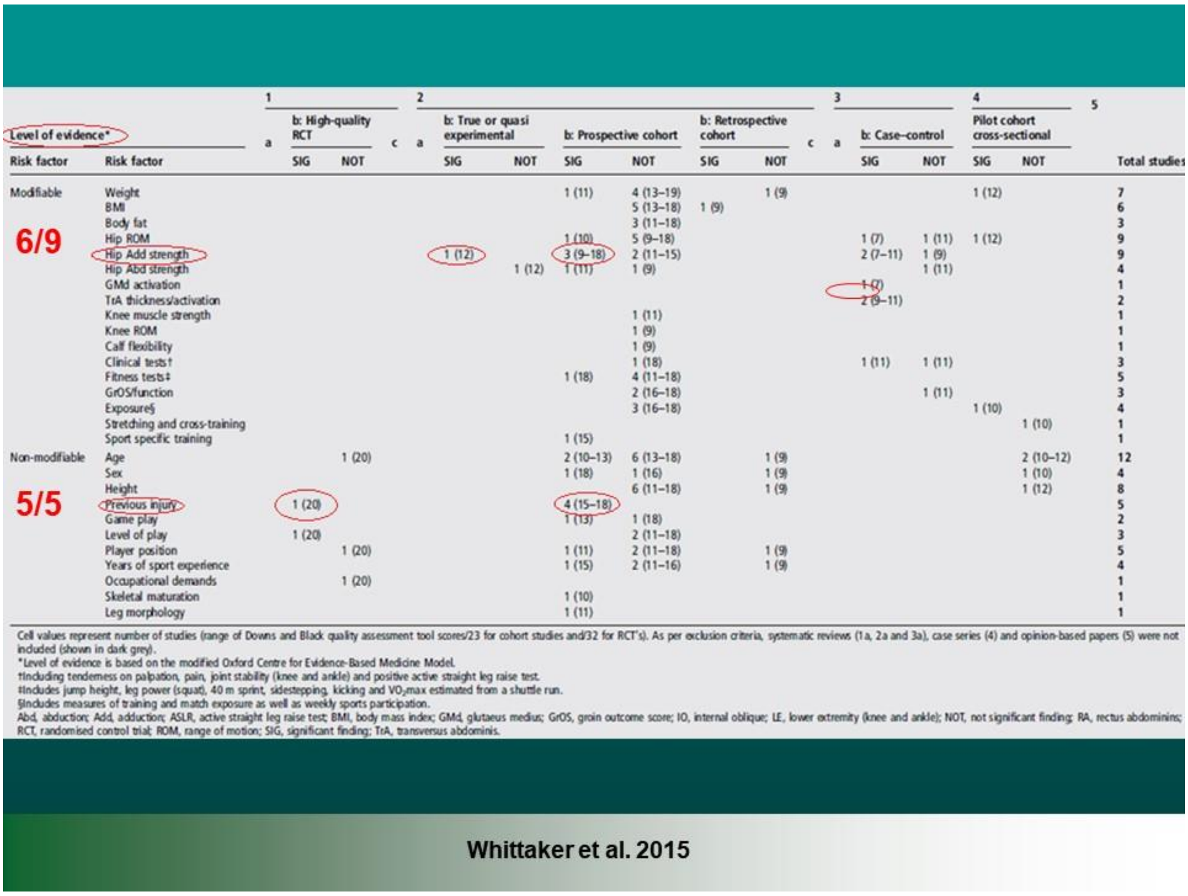
Groin and hip injuries continue to be a major problem in professional football and other sports that require kicking and twisting movements and often lead to prolonged pain and have a high recurrence rate. Specific sports have a high incidence of groin and hip pain (Anderson, 2014; Epstein et al., 2013; Kuhn et al., 2016; Philippon et al., 2013; Ryan et al., 2014; Tyler et al., 2001). It is thus imperative to take cognisance of the risk factors involved with all the different sports (and positions therein) which is the basis of a prevention strategy. Southampton Football Club have been the first club to devise a prevention strategy for groin and hips for their players, with excellent success and they have explained that the most important strategy for prevention is the identification of risk factors leading to groin and hip pathologies.

Slide 277



The importance of identification of injury risk factors was presented by Jackie Whitaker at a Conference in 2015 (Slide 277). This follows on from the Van Mechelen model (1997), as well as that of Van Tiggelen et al. (2008). These expansions of Van Mechelen's model leads to a more global model which gives a better insight into the different processes for injury prevention that can be used by clinicians, coaches and managers. Further, the systemic review by Whittaker et al. (2015) identified specific risk factors for groin injuries in sports which have been referred to in previous studies.

<u>Slide 278</u>



		1				2								3			4		5	
Level of evidence*		a	b: High-quality RCT		c	a	b: True or quasi experimental		b: Prospective cohort		b: Retrospective cohort		c	a	b: Case–control		Pilot cohort cross-sectional			
Risk factor	Risk factor		SIG	NOT			SIG	NOT	SIG	NOT	SIG	NOT			SIG	NOT	SIG	NOT		Total studies
Modifiable	Weight								1 (11)	4 (13–19)		1 (9)					1 (12)			7
	BMI									5 (13–18)	1 (9)									6
	Body fat									3 (11–18)										3
6/9	Hip ROM								1 (10)	5 (9–18)					1 (7)	1 (11)	1 (12)			9
	Hip Add strength						1 (12)		3 (9–18)	2 (11–15)					2 (7–11)	1 (9)				9
	Hip Abd strength							1 (12)	1 (11)	1 (9)						1 (11)				4
	GMd activation														1 (7)					1
	TrA thickness/activation														2 (9–11)					2
	Knee muscle strength									1 (11)										1
	Knee ROM									1 (9)										1
	Calf flexibility									1 (9)										1
	Clinical tests†									1 (18)					1 (11)	1 (11)				3
	Fitness tests‡								1 (18)	4 (11–18)										5
	GrOS/function									2 (16–18)						1 (11)				3
	Exposure§									3 (16–18)							1 (10)			4
	Stretching and cross-training																	1 (10)		1
	Sport specific training								1 (15)											1
Non-modifiable	Age			1 (20)					2 (10–13)	6 (13–18)		1 (9)						2 (10–12)		12
	Sex								1 (18)	1 (16)		1 (9)						1 (10)		4
	Height									6 (11–18)		1 (9)						1 (12)		8
5/5	Previous injury		1 (20)						4 (15–18)											5
	Game play								1 (13)	1 (18)										2
	Level of play		1 (20)							2 (11–18)										3
	Player position			1 (20)					1 (11)	2 (11–18)		1 (9)								5
	Years of sport experience								1 (15)	2 (11–16)		1 (9)								4
	Occupational demands			1 (20)																1
	Skeletal maturation								1 (10)											1
	Leg morphology								1 (11)											1

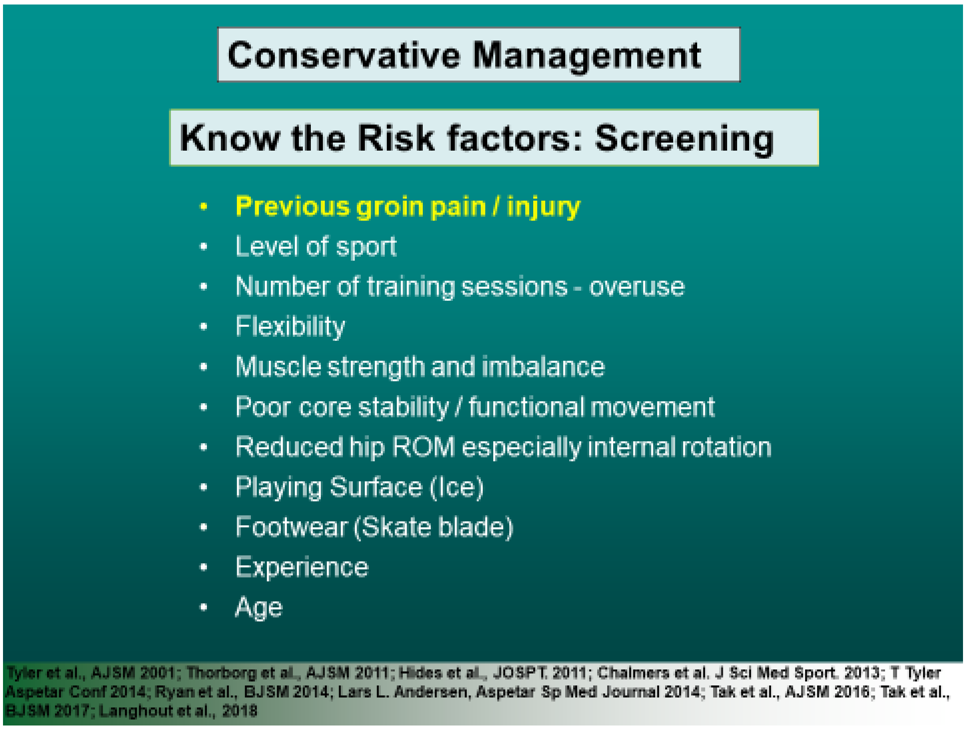
Cell values represent number of studies (range of Downs and Black quality assessment tool scores/23 for cohort studies and/32 for RCT's). As per exclusion criteria, systematic reviews (1a, 2a and 3a), case series (4) and opinion-based papers (5) were not included (shown in dark grey).
*Level of evidence is based on the modified Oxford Centre for Evidence-Based Medicine Model.
†Including tenderness on palpation, pain, joint stability (knee and ankle) and positive active straight leg raise test.
‡Includes jump height, leg power (squat), 40 m sprint, sidestepping, kicking and VO_2max estimated from a shuttle run.
§Includes measures of training and match exposure as well as weekly sports participation.
Abd, abduction; Add, adduction; ASLR, active straight leg raise test; BMI, body mass index; GMd, glutaeus medius; GrOS, groin outcome score; IO, internal oblique; LE, lower extremity (knee and ankle); NOT, not significant finding; RA, rectus abdominins; RCT, randomised control trial; ROM, range of motion; SIG, significant finding; TrA, transversus abdominis.

Whittaker et al. 2015

The main risk factors for groin injury in sports include previous groin injury, reduced relative hip adductor strength and reduced sport-specific training (Whitaker et al., 2015) (Slide 278). The only modifiable risk factor associated with groin pain was strength and the only non-modifiable risk factor was previous injury. Unfortunately, the findings of this study are limited by the quality of the studies and the variables assessed in each study. There are some inconsistencies in the research with regards to how strength is measured. While the Adductor Squeeze Test was the most frequently used test, other strength tests such as dynamometers and isokinetic equipment have been utilised.

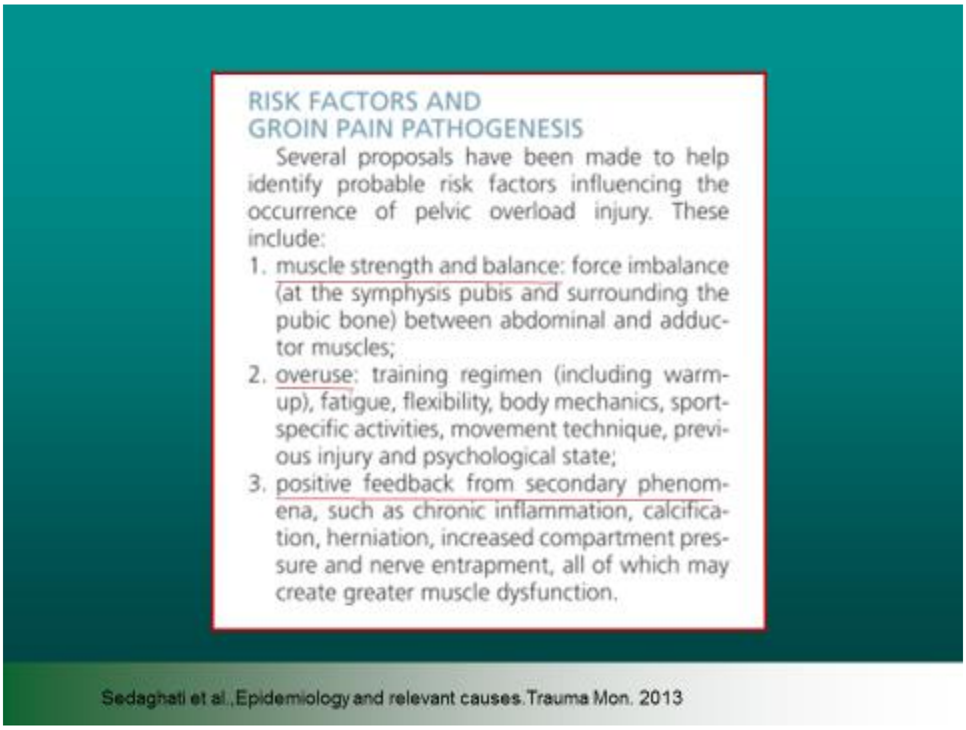
There are limited prospective studies that evaluate musculoskeletal risk factors, particularly with regards to motor control risk factors for hip and groin pain. Further studies demonstrating that previous injury and strength were the biggest risk factors for hip and groin injury include Verrall, (2007) - Australian male football players; Malliaris et al., (2009) - Australian Rules football and soccer; Crow et al., (2010) - elite junior Australian football players; Engebretsen et al., (2010) – soccer players; Nevin and Delahunt, (2014) - Gaelic Football and Ryan et al., 2014 – field based sports. In addition, Ryan et al. (2014) reported that older age, higher BMI and reduced hip abductor range of motion were risk factors for groin and hip injury in field-based sport. Further, maintenance of an adequate diet, regular routines for sleep, and use of protective equipment are essential factors which appear to underpin most preventative strategies. Also the clinician should be aware of age, gender, experience, or other socio-demographic or sports-related risk indicators (Jacobsson and Timpka, 2015).

Slide 279



Some basic risk factors for groin and hip pain are demonstrated in Slide 279. I tend to give a long discussion on this aspect in my presentations, as each is important and there are many more risk factors. Even if there are not specific studies to back these factors, I believe that a thorough and intensive assessment (risk identification) is critical when aiming to formulate a prevention strategy for groin and hip pain. Further, as has been stated previously, clinicians require a thorough understanding of the entire kinetic chain and the possible adaptations / mal-adaptations due to functional instability and/or previous injuries.

Slide 280



Sedaghati et al. (2013) summarised risk factors most succinctly, which focused on the most relevant points including muscle strength and balance, overuse and muscle dysfunction (Slide 280). Risk factors for groin injury during football kicking were specifically highlighted by Andersen (2014). He described the five kicking phases and concluded that the highest risk of groin injury occurs during the backswing and leg cocking phases, where the hip and groin muscles work eccentrically at high intensity and velocity. The mechanism of adductor injuries was further demonstrated by Serner et al. (2019), as shown in Chapter 9 – Rehabilitation. Understanding these movements could be a useful guide for clinicians to analyse the specific mechanism and strengthen the relevant muscles accordingly in order to prevent these injuries. From my experience, it is often the case that “groin pain” is as a result of the football player being weak in their adductor muscles, particularly in the kicking phase. A meaningful and practically applicable literature review undertaken by Soerel (2017), demonstrated evidence-based exercises or exercise programmes to target identified risk factors for groin injuries in young male football players. He found effective interventions to target each identified modifiable risk factor.

From my experience, I would name muscle imbalance, biomechanical mal-adaptations and the resultant neuro-motor control as major risk factors. Very often, correcting these biomechanical mal-adaptations and educating the patient on the correct feedback / feedforward neuro-motor control system, can rectify any mal-adaptations and prevent groin/hip (and other) pain developing. I have evolved my management of athletes with hip and groin potential problems these past years. A few examples are Gluteus Medius and Minimus stabilisation, Gluteus Maximus strengthening such as bridging or thrust exercise and strengthening Adductor muscles in relevant ranges for the particular sport.

10b. Risk factors - Load

Sports medicine and science staff have a number of monitoring tools available to track how much work an athlete has performed, the response to that work and whether the athlete is in a relative state of fitness or fatigue. The volume of literature, coupled with clever marketing around the 'best approaches' to optimising athlete performance, has resulted in practitioners having more choices than ever before.

As shown in Table 23, emerging evidence indicates that poor load management is a major risk factor for injury.

Table 24: General Load – Basic observations

Author	Discussion	Outcome
Jones N, (Arsenal Conference) (2015).	**Identifying loads**	**The importance of identifying the different loads** i.e. internal and external load in Rugby Union.
Soligard et al., Part 1. (2016); Schwellnus et al., Part 2. (2016).	**International Olympic Committee Consensus statement**	**Guidelines prescribing training and competition load**, as well as for **monitoring of training, competition and psychological load, athlete well-being and injury.**
Drew et al. (2016)	**(a) PREVENTION**	a) **Primary prevention** involves **screening for pre-participation load risk factors**, such as low training loads, prior to a training period or competition. b) **Secondary prevention involves screening for workloads** that are known to precede an injury so that modification can be undertaken to mitigate this risk. c) **Tertiary prevention** involves **rehabilitation practices that include a graded return to training** programme after injury to reduce the risk of sustaining a subsequent injury.

Drew et al. (2016)	**(b) PREVENTION**	Load management must also be based on **controlling and reducing the risk factors** for the development of a sports injury. **This is most pertinent for groin and hip problems and particularly in the young athlete.**
Windt and Gabbett, (2017)	**Training load**	The association of training loads with **injury incidence**
Bourdon et al. (2017)	**Internal load**	Relative biological (both physiological and psychological) stressors imposed on the athlete during training or competition. Measures such **as heart rate, blood lactate, oxygen consumption, and ratings of perceived exertion are commonly used to assess internal load**
Bourdon et al. (2017).	**External training loads**	The common objective measures of external load included **power output, speed, acceleration, time–motion analysis, global positioning system parameters, and accelerometer derived parameters**.
Light, (2019).	The effect of load on **specific muscles** around match play.	Changes in **adductor strength and flexibility** before, during and immediately after soccer match play, showed that university soccer players exhibited **decreasing adductor squeeze test and Bent Knee Fallout Values as the soccer match duration increases.**

It is imperative to note that load monitoring, without concurrent management of training loads, is not sports injury prevention. Clinicians and strength and conditioning experts may also be able to prevent the risk of fatigue-related injury.

I have observed over my professional career the disparity of the use of these tools for monitoring load. So much depends on the finance involved and then the expertise for analysing and interpreting the findings. Having worked with elite athletes where they are funded, I also work in the disadvantaged community in South Africa, where they require simple knowledge of this load as they cannot afford the equipment.

There are common misconceptions regarding load management and I believe it is essential for the clinician to take cognisance of the valuable comments as stated in Table 24.

Table 25: Load

Author	**Relevant comments**
Materne et al. (2014).	The importance of an **appropriate balance between volume, intensity and rest period during the growth spurt in the development of elite youth soccer players.** The demonstrated that there were more growth-related injuries, less muscle injuries and a peak injury incidence in the U15 Qatari male soccer players team. The results suggest **that somatic maturation is a potential risk factor in highly trained youth soccer** players as during the growth spurt players have a higher vulnerability of injuries.
Gabbett et al. (2016).	**Increased injury risk was associated with spikes in workload (i.e. over-loading) and low chronic workloads** (i.e. under-loading), which may leave an athlete predisposed to a spike in workload. Further he states that, **"If overuse injury is a 'training load error', should undertraining be viewed the same way?**"
Gabbett et al. (2016).	To optimally prepare for competition demands, athletes need to **(gradually) increase their workloads so that their fitness (chronic workload) is sufficient to overcome acute fatigue demands**. They hoped that sport science, coaches, strength and conditioning, and health professionals would see the value in the acute: chronic workload ratio and incorporate this form of monitoring into their day-to-day training environment.
Gabbett Performance Solutions (2017)	**High loads can actually be protective against injury**, while **"over-resting" may actually increase the risk of injury.**
Gabbett T. (2017).	**Trainers, coaches and clinicians should rather than obsessing over playing minutes, focus more on the quality and quantity of training** that is performed in preparation for those minutes. Importantly, there should be adequate time for recovery and preparation.
Gabbett T. (2017).	**There is no crystal ball to predict injuries**
Gabbett T. (2017).	Load monitoring helps to document training and competition demands, but simply knowing the risk would not reduce injuries. **Players experiencing high loads need to reduce their load, while a player with consistent low loads would need to gradually increase their loads to prevent injury.**
Gabbett T. (2017).	They suggested that **viewing external workload, internal workload, perceptual well-being and readiness to train/compete data in combination provides more meaningful individual training prescriptions than making interpretations based on data from any single athlete monitoring tool in isolation.**
Bowen et al. (2017).	Higher accumulated and acute workloads were associated with a greater injury risk. **However, progressive increases in chronic workload may develop the players' physical tolerance to higher acute loads and resilience to injury risk.**
Windt and Gabbett, (2017)	**Players who participated in a greater number of pre-season sessions had a lower likelihood of injury throughout the competitive season** A paradigm shift was needed where clinicians appreciated that total external training load (distance covered) is not necessarily associated with increased injury risk and may in fact decrease risk. However, one should take into account that **greater percentages of time spent at high speeds in a given training week may increase injury risk in the current or subsequent week,** especially when preseason participation is low

Gabbett and Whitely, (2017)	Generally **medical staff are at fault for incorrectly reducing training loads**, and **physical preparation staff are at fault of inappropriately working players too hard** when incomplete understanding of the 'train smarter and harder' approach is present.
Franklyn-Miller et al., (2014); Quarrie et al., (2017); Martinez-Silvan et al., (2017); Williams et al., (2016); Weaving et al., (2017) and Bowen et al., (2017).	Athlete monitoring has become **critical in the high-performance sporting environment and the possibility of preventing injuries**
Murray, (2017)	Management of training load in **young athletes was fundamental** to guarantee a long sporting career and/or engagement in sporting activities. The choice of monitoring techniques and methods should be determined by what is important to the **sporting context and the individual situation** taking into account social/behavioural norms.
Weston, M. (2018)	A specific questionnaire which **assessed factors influencing training planning, training load practices, and training load feedback** and usefulness was sent to coaches and practitioners. The result showed that coaches and practitioners perceived training load monitoring as worthwhile, with **differences in practices and perceptions likely reflecting club infrastructure.**
Fanchini et al. (2018)	Stated that **despite association, the acute: chronic workload ratio did not predict non-contact injury in elite footballers**. Although the acute: chronic markers showed association, this was with poor prediction ability.
Bowen et al. (2019)	Recommended that **practitioners involved in planning training for performance and injury prevention, monitor the acute: chronic workload, increase chronic exposure to load** and avoid spikes that approach or exceed 2.0 (Relative Risk = 5.4– 6.6).

The range of different practices used in sport and the lack of agreement between parties emphasise the importance of having a clear rationale for athlete monitoring (Table 25). According to Gabbett et al., (2017), the daily monitoring of the acute: chronic workload ratio has been found to be a valid tool for injury risk management in Australian football.

My overview is that workload monitoring is not as simple as recording individual hours and intensity of sports participation and monitoring. This data needs to be seen in the light of other factors like the specific individual and their psychological profile, the base cardiovascular fitness of that individual, sleep patterns and current fatigue. I also believe that the relationship between the Medical staff and the Coach is absolutely essential with regard to load. With the Stormers rugby, the coach would question all my decision-making in a most constructive way. He would then agree with the decision (such as a player having to rest his injury), only if it was explained clearly and backed by appropriate clinical reasoning, as well as evidence based medicine. This collaboration between all medical staff and the coach was an ongoing daily procedure and this would definitely be of value when discussing load management.

There is major difficulty for future research to define appropriate training doses and risk thresholds for young athletes to make sure that modern coaching approaches are employed to develop resilient athletes and reduce the risk of burnout. This is due to the individual factor, as well as position specific factor. Occasionally, I tend to see the coach / fitness trainer "ticking" all the right boxes and not truly understanding the load implications. Education thereof is vital.

The physiotherapist from Blackburn Rovers provided me with his experienced advice on load and the athlete (D. Fevre, personal communication, August 14, 2015). I relate his comments as below:

"With regard to loading, our player's data is taken from the 'Catapult' GPS system. This applies to the first team and U-21 squads age range 17-34. Key components we look at over the week's training include:

- *High Intensity Distance*
- *Changes in Direction*
- *Player Load*
- *Red Zone (Cardiac Load 85-100% of Max.HR)*
- *Extensity of Session*
- *Intensity of Session*

All this data can then be rolled into one absolute 'Total' figure. A player's individual diary can then be built up and as of this season players are allowed to wear GPS in league matches (it used to be only friendly matches). Unfortunately, in our first 2 games only 1 player was happy to wear a unit in the match!!

With regard to the Academy they follow the same structure but under the elite player performance plan they have to fulfil 26 hours of football 'work'. This ironically doesn't include pre-habilitation and swimming sessions"!!

The physiotherapist from Manchester City Academy sent me the following points regarding load and the young athlete (G. Downie, personal communication, February 12, 2015):

"We work in four week cycles & all load is progressive but planned over a four year cycle.
Each day has a different theme from high intensity, sprint distance, recovery but all are on the

pitch with balls in football sessions so no divide technical/physical.
They do pre-act daily, gym conditioning X2 weekly, yoga X1 weekly & alternate sports x1 weekly...
Load compromised if peak height velocity is an issue but will still train...less intensity".

Regarding hips and groin and prevention of injuries, when asked for a pearl of wisdom, Adam Weir (2016) responded to my enquiring e mail with the following: *"Management of groin and hips, in my opinion - load management is key."*

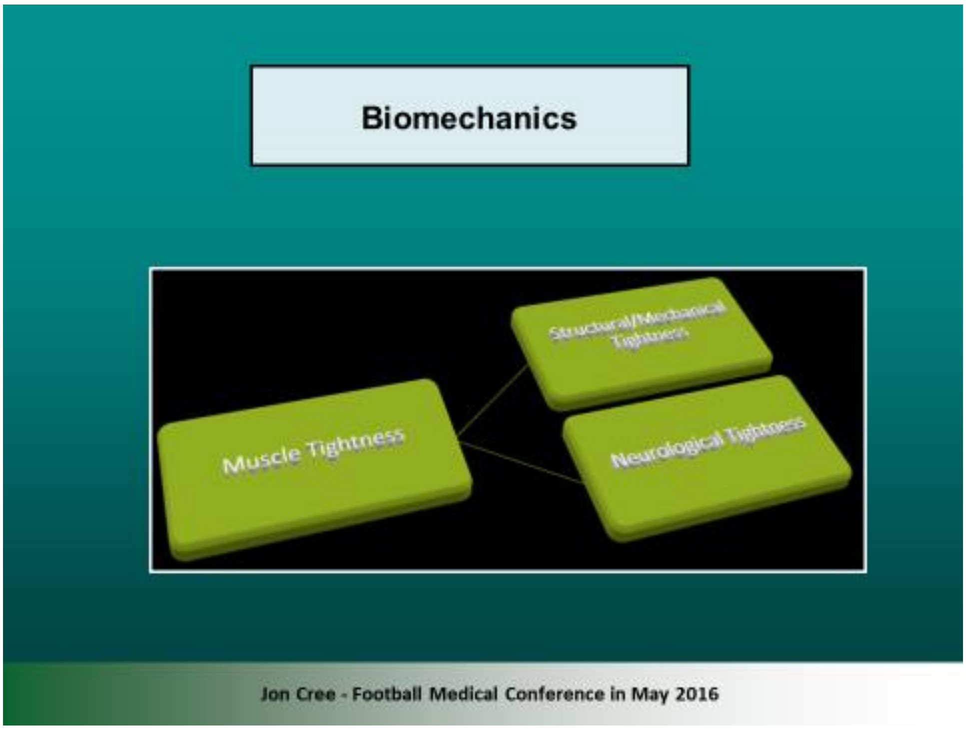
It is useful to obtain advice from the clinicians in the field with their invaluable experience. However, one should be aware that this is an ever-changing area as I have realised over 13 years of working with all the Premier League sides and observing this evolving scenario. It is important to keep up to date with the latest changes both in the evidence based medicine world as well as the practical world. One should be open to change, but clinicians must be careful not to jump from one new technology to another, as much of the benefits of all these monitoring tools are the individual trends that are picked up from observing players data over time.

Thus, workload monitoring is essential, but it is a developing science and still requires more input from the training and medical team, with particular attention to the youth in sport.

10c. Risk factors – Biomechanics

An understanding of the biomechanics of the entire kinetic chain is the corner stone for prevention and treatment of athletes. As mentioned previously (Chapter 4 – Functional Anatomy), the clinician's in-depth knowledge of all the implications of the interconnectedness of all the muscles, joints and fascia in the body is essential.

Slide 281

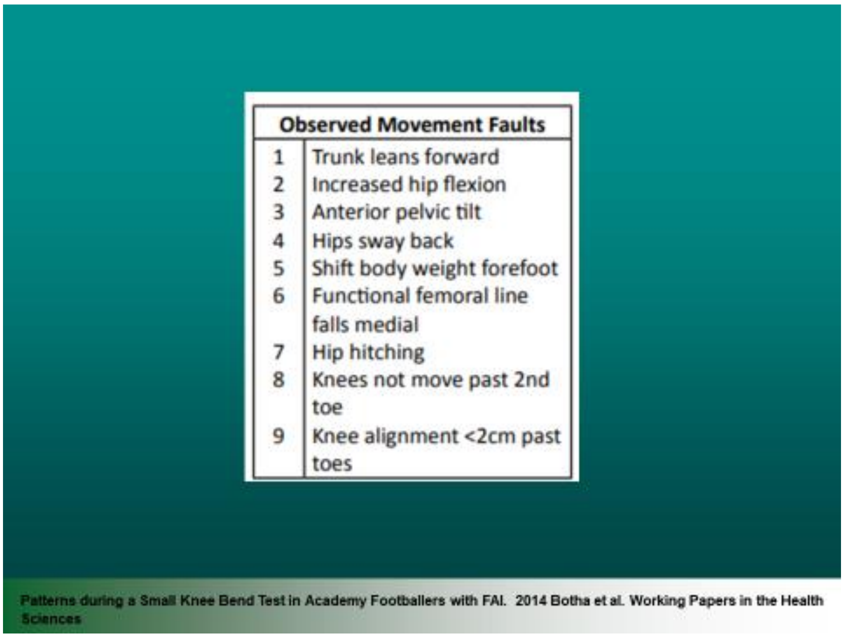


As shown on Slide 281, Jon Cree presented on hip injury prevention strategies, particularly regarding addressing movement patterns and anterior pelvic tilt (Football Medical Association Conference, Midlands, England, UK, 2016). He advised attendees to correct alignment and to increase the posterior chain control which should be done at speed /unilaterally /eccentrically. Further, he discussed mechanical / structural and neurological tightness and the resultant implications, all of which should be taken into consideration when preventing or rehabilitating groin and hip pain. The body adapts to these weaknesses / tightness which may lead to various musculo-skeletal problems and groin and hip pathologies. This is why I believe strongly in pre-screening for all athletes, in spite of this being disputed by Roald Bahr (2016). Having organised an in-depth musculo-skeletal screening programme for the Stormers rugby team, albeit anecdotal, I was aware of the improved strength of the kinetic chain and particularly around the pelvic area which may have prevented injuries to a degree.

The relevance of groin pain and biomechanics of maintaining lumbo-pelvic position has been highlighted in studies e.g. McCarthy et al. (2017) - ability to maintain lumbo-pelvic position differed between the involved and uninvolved legs; Ng et al. (2018) - patients with FAIS showed a higher pelvic incidence; Casartelli et al. (2018) - movement-pattern quality of patients with FAIS should be rated by a highly experienced clinician and Beneck et al., 2018; Van Goeverden et al., 2019 - the pelvic tilt /rotation has a strong influence on hip congruence.

Consideration of these biomechanics around the pelvis and hips and the possible effect this may have on the entire kinetic chain and other lower extremity pathologies is necessary. Further, as has been mentioned, these consequences of incorrect posture should always be taken into consideration in activities of daily living, as well as for the specific sport.

Slide 282



A correction strategy once these specific faulty movements have been identified (Slide 282), is most useful when screening or assessing an athlete for a prevention strategy e.g. posture correction, the hip hike exercise, lunge and proprioception exercises.

10d. Risk factors - Hip Range of Motion

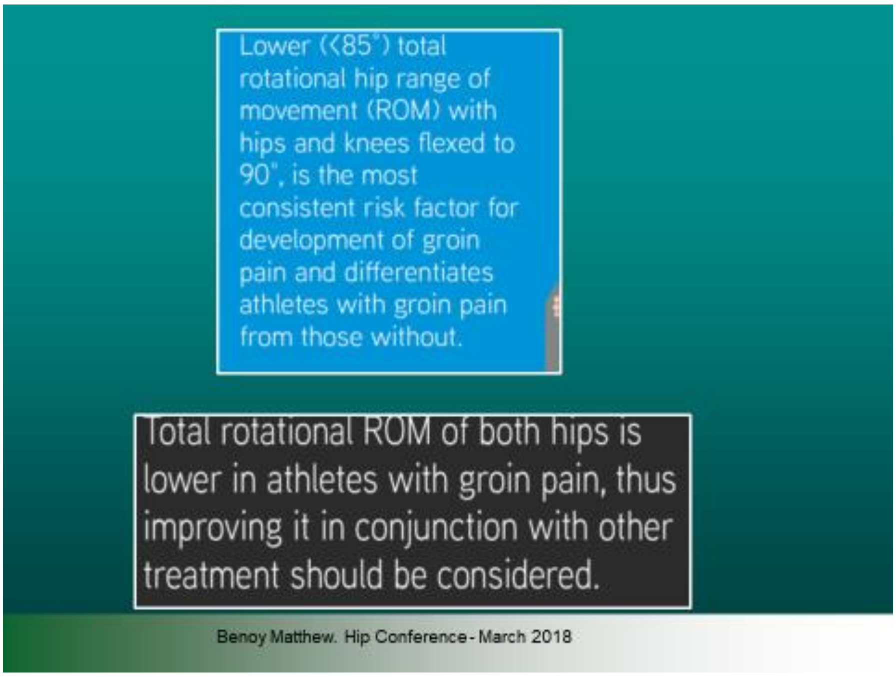
As has been discussed previously, most studies concur that a low hip range of motion may be a precursor to hip and groin pain in sports men and women (Tak et al., 2016).

Slide 283

The infographic from Tak et al. (2017) concludes that there is strong evidence that lower hip range of motion of **both hips** is a risk factor for the development of groin pain (Slide 283). They declared that no published prevention or treatment programs for groin pain in athletes focuses specifically on hip range of motion, but if hip range of motion and groin pain are related, this may provide insights for possible prevention strategies in athletes. However, Brunner et al. (2016 – youth ice hockey players) and Murphy et al. (2017 - semi-elite Australian footballers) declared that screening hips using clinical measures to detect CAM morphology associated with poor hip range of motion may be inaccurate. Thus this correlation between hip range of motion and the degree and relevance of CAM morphology remains controversial in the literature (Freke et al., 2016; Mosler et al., 2018).

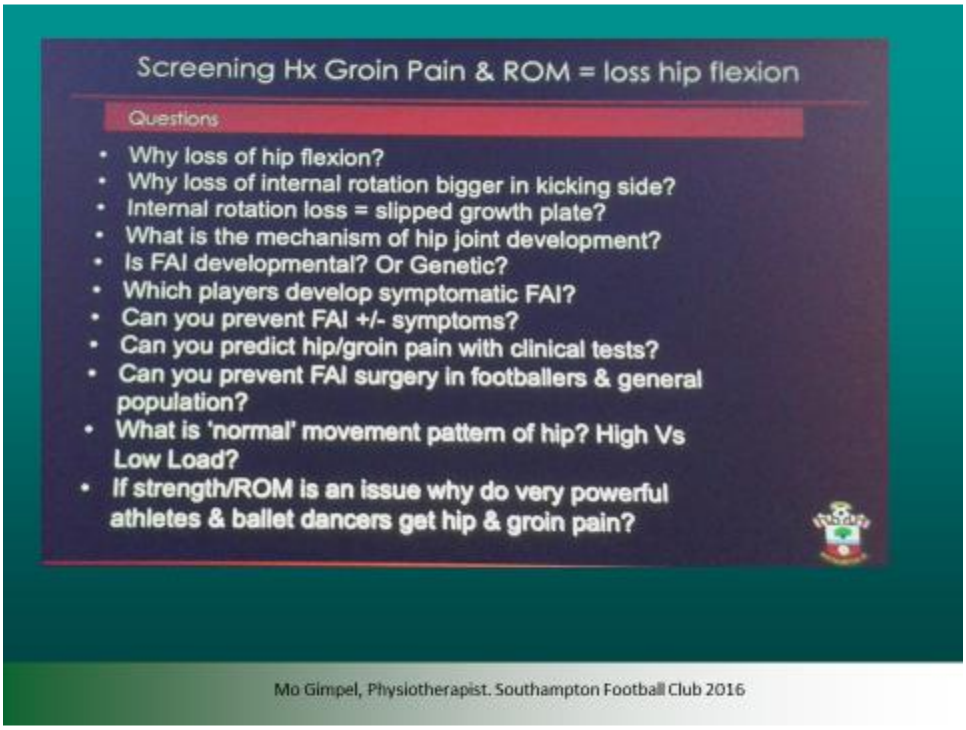
As hip injuries are being more frequently recognised in high level tennis players, with up to a quarter of injuries occurring in the pelvis/hip/groin, it is imperative that in order to have a successful prevention outcome, as with all sports, the biomechanics involved need to be analysed and specific strengthening and stretching exercises given related to the game (Young et al., 2014). Moreno-Pérez et al. (2016) recommended that clinicians should include specific exercises in their conditioning, prevention and rehabilitation programmes aiming to avoid restricted mobility of hip flexion, extension, abduction and internal rotation that was shown to be generated as a consequence of playing tennis. I believe it is plausible to do hip mobilisations and general stretching and strengthening of the relevant muscles related to their sport.

<u>Slide 284</u>



Most significant is the explanation from Benoy Matthew (Conference on Hip and Groin London, UK, 2018), where he specified that a lower **total** rotational hip range of motion with hip and knees flexed to 90 degrees, was the most consistent risk factor for the development of groin pain and differentiates athletes with groin pain from those without (Slide 284). He was not convinced that limited internal range of motion was the specific problem and requires consideration.

Slide 285



These questions regarding hip range of motion were precisely discussed by Mo Gimpel as demonstrated on Slide 285. (Warwick Sports Hip Meeting, National Football Centre, St George's Park, Burton-on-Trent, Staffordshire, UK. 2016). The ensuing discussion with the panel was interesting and demonstrated how much further one has to go to really understand all these implications and whether the clinician needs to "improve" the hip ROM to prevent hip pathologies.

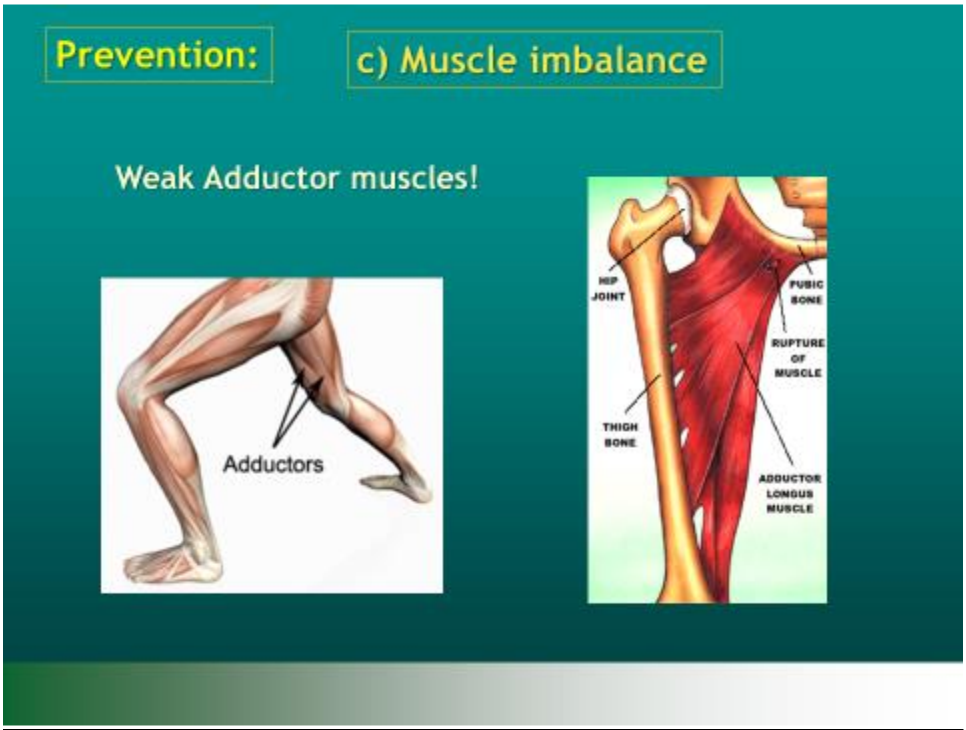
10e. Risk factors - Neuro motor control

The key and foundation to all movement is that of neuro-motor control. This was comprehensively explained in Chapter 4 – Functional Anatomy. Enhanced proprioceptive feedback strengthens synergistic muscle groups and stabilizes the coordination of limbs, thus contributing to the movement efficiency. Many studies demonstrate this factor of neuro-muscular / proprioceptive control of kinetic movement, although the studies embrace all areas of the body and not only that of the groin and hip area (Cowan and Crossley, 2009; Horobin and Thawley, 2015; Martelli et al., 2011; Mendis and Hides, 2016).

10f. Risk factors - Muscle function

Risk factors to be considered for groin and hip pain are those of muscle weakness and muscle imbalance (Casartelli et al., 2016). They declared that future research should investigate the relationship between hip muscle weakness, functional disability and overuse injury risks. The assessment and treatment options for potential pelvic movement control deficits are not well established and certainly require further investigations.

Slide 286



Past studies have consistently found previous groin injury and weakness of the adductors to increase the risk for time-loss groin injury (Slide 286). However, these findings have not resulted in effective preventive measures that reduce groin injuries in professional football players. Besides previous groin injury, previous injury to locations other than the groin should be considered as risk factors for subsequent groin injury (Langhout, 2018).

Although there has been some research on this topic (Crow et al., 2010; Engebretsen et al., 2010; Haroy et al., 2017; Haroy et al., 2019; Rafn et al., 2016; Thorborg et al., 2014), it would be useful for research to be specific for the different demands in different sports and positions therein.

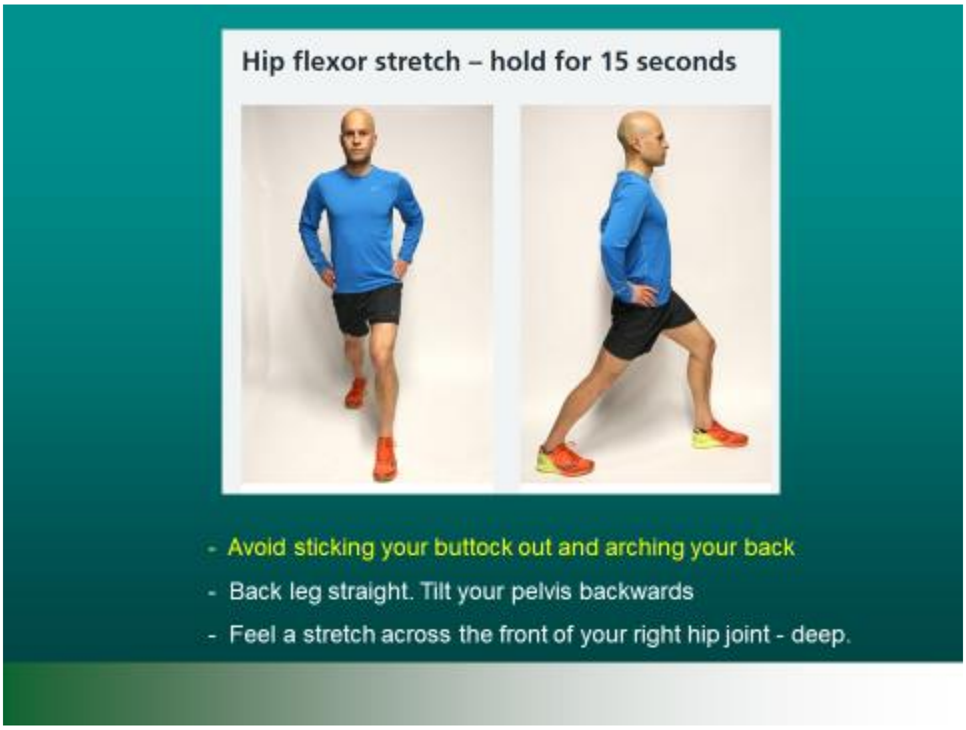
10g. Risk factors - Warm up / Flexibility

There are many studies regarding warm-up and stretching, but minimal regarding groin and hips. Soligard et al. (2008), indicated in their study that a structured warm-up programme can prevent lower extremity injuries in young female football players. Al Attar et al. (2016) designed a comprehensive warm-up programme targeting muscular strength, body kinaesthetic awareness, and neuromuscular control during static and dynamic movements to decrease injury risk for soccer players and found that the use of F-MARC injury prevention programs, particularly the '11+' program, decreased the risk of injuries among soccer players. Vazini and Parnow, (2017) showed that a soccer specific warm-up protocol using dynamic stretching was preferable in enhancing performance, compared to protocols relying on static stretches and FIFA 11+ program.

There are useful warm-up/stretching exercises for groin and hip prevention which I have been undertaking with all the sports teams under my care. This would include kinetic movement (revised yoga "Sun Salutations") prior to and after training or matches. The yoga movement appeared to make the South African hockey players stronger and more flexible and I believe, helped with neural mobilisation. The contract / relax method of stretching made a difference (anecdotal) to the forwards in Super 14 rugby before training and matches. Even though there is no EBM to back these specific warm up/stretching procedures, they may be of value if implemented based on clinical reasoning and experience.

Furthermore, the importance of flexibility of the muscles around the pelvis has been discussed previously and shown to be crucial for the correct biomechanical movement patterns. Individuals with hip flexor muscle tightness appear to utilize different neuromuscular strategies to control lower extremity motion. This may have an effect on groin, hip and lower extremity muscles and joints.

Slide 287



A specific hip flexor stretching exercise that I have been using in all teams is seen in Slide 287. Mostly, athletes are shown the kneeling stretch, which in my opinion cannot be as effective, as it will primarily stretch the Rectus Femoris. Further, it is not a functional position and can place huge pressure on the patella femoral joint (as with the large rugby players).

Conclusion: Risk Factors

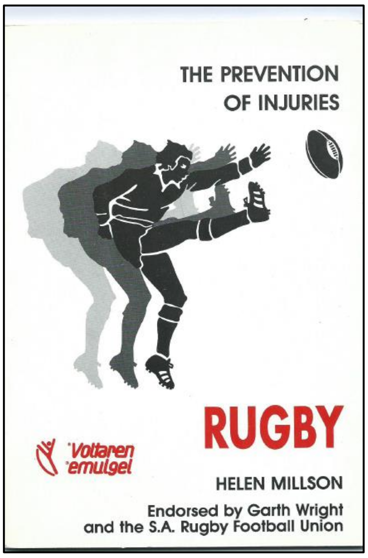
Groin injuries are common in athletes and constitute a considerable part of all time-loss injuries in men's professional football and other sports. Understanding the risk factors for players is fundamental in order to develop and implement injury prevention strategies for groin and hip pathologies (Pizzari et al., 2008). I concur with the study by Werner et al. (2019) who declared that it would be beneficial if future studies focused on developing and evaluating pre-participation screening and groin injury prevention programmes through high-quality randomised controlled trials.

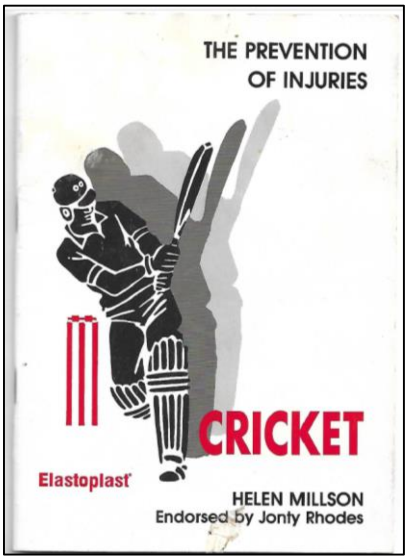
Chapter 11. Prevention of Hip and Groin Injuries:

11a. Introduction

Many years ago (1992), I published 2 Handbooks for Prevention of Rugby and Cricket injuries, meant specifically for schools, clubs and sports people in the community / rural areas (Slide 288). I also contributed to a Cricket Manual authored by Yusuf Hassan with discussion on prevention tactics. 2 of my published studies on Rugby injuries – "The nature and incidence of injuries in a Currie Cup rugby team from 2001 to 2003 (Millson et al., 2005) and Training volume and injury incidence in a professional rugby union team (Viljoen et al., 2009) were undertaken to get an idea of the injuries and thus prevent them going forward.
These were not specific groin and hip injuries but were insightful for all injuries. Thus I have always been devoted to this strategy of preventing injuries and enhancing performance.

Slide 288





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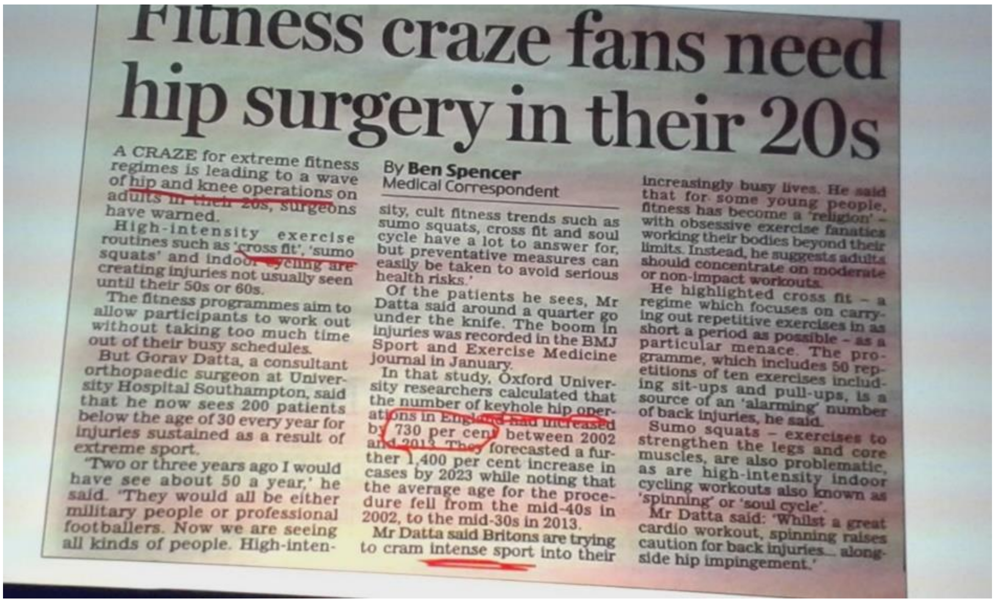


Fitness craze fans need hip surgery in their 20s

By Ben Spencer
Medical Correspondent

A CRAZE for extreme fitness regimes is leading to a wave of hip and knee operations on adults in their 20s, surgeons have warned.

High-intensity exercise routines such as 'cross fit', 'sumo squats' and indoor cycling are creating injuries not usually seen until their 50s or 60s.

The fitness programmes aim to allow participants to work out without taking too much time out of their busy schedules.

But Gorav Datta, a consultant orthopaedic surgeon at University Hospital Southampton, said that he now sees 200 patients below the age of 30 every year for injuries sustained as a result of extreme sport.

'Two or three years ago I would have see about 50 a year,' he said. 'They would all be either military people or professional footballers. Now we are seeing all kinds of people. High-intensity, cult fitness trends such as sumo squats, cross fit and soul cycle have a lot to answer for, but preventative measures can easily be taken to avoid serious health risks.'

Of the patients he sees, Mr Datta said around a quarter go under the knife. The boom in injuries was recorded in the BMJ Sport and Exercise Medicine Journal in January.

In that study, Oxford University researchers calculated that the number of keyhole hip operations in England had increased by 730 per cent between 2002 and 2013. They forecasted a further 1,400 per cent increase in cases by 2023 while noting that the average age for the procedure fell from the mid-40s in 2002, to the mid-30s in 2013.

Mr Datta said Britons are trying to cram intense sport into their increasingly busy lives. He said that for some young people, fitness has become a 'religion' – with obsessive exercise fanatics working their bodies beyond their limits. Instead, he suggests adults should concentrate on moderate or non-impact workouts.

He highlighted cross fit – a regime which focuses on carrying out repetitive exercises in as short a period as possible – as a particular menace. The programme, which includes 50 repetitions of ten exercises including sit-ups and pull-ups, is a source of an 'alarming' number of back injuries, he said.

Sumo squats – exercises to strengthen the legs and core muscles, are also problematic, as are high-intensity indoor cycling workouts also known as 'spinning' or 'soul cycle'.

Mr Datta said: 'Whilst a great cardio workout, spinning raises caution for back injuries... alongside hip impingement.'

There has been a high incidence of groin and hip injuries, coupled with a dramatic increase in surgery over the past decade (Slide 289). This is particularly true in elite sport where a "quick fix" is the guiding force. Thus, it is imperative for clinicians to work on both ends of the injury spectrum, including prevention of the initial injury and fully functional rehabilitation post-injury. The use of functional screening tools, early detection, and following proper treatment protocols are essential for clinicians to provide the highest level of care. Further, detailed medical history pertaining to previously sustained hip injuries are instrumental in providing these athletes with the best chance to participate without being re-injured.

Light et al. (2018) examined hip and groin injury management in English youth football and found that most, but not all responding academies, address prevention, screening and return to play in their management of hip/groin injuries. This has only been the case in the past few years and is slowly being recognized and implemented and is one of my main reasons for undertaking this professional doctorate. In 2012, a number of medical doctors working with specific Premier League teams asked me to write up an evidence-based Handbook on groin and hips and subsequently requested that I undertake a PhD, as they were somewhat concerned by the number of these groin and hip problems and the non-consensual management for these pathologies.

Holmich et al. (2000), showed the risk of a groin injury to be reduced by 31% by undertaking specific exercises, but felt that this reduction was not significant. However, they stated that a univariate analysis showed that having had a previous groin injury almost doubles the risk of developing a new groin injury and playing at a higher level almost triples the risk of developing a groin injury. Thus groin injuries continuously constitute a major problem and further studies into prevention of groin injuries is required. This thesis adds knowledge to show that a prevention strategy for groin and hip pain is possible.

Apart from the costs involved in elite sport, lower injury rates have been linked with team success in national and international matches. Thus, avoiding injuries ensures high player availability and allows coaches to have the best squad for matches (Ekstrand et al., 2016).

11b. Background

Over the past years a number of studies have recommended injury prevention programmes (Table 256.

Table 26: Injury Prevention Programmes

Author	Outcome
Esteve et al. (2015)	The aim of this systematic review was to evaluate the effect of **specific groin-injury prevention programmes** in sports. Resultant meta-analysis revealed a potential clinically meaningful groin injury reduction of 19% -52%.
Soomro et al.(2016)	The underlying explanations for IPP benefits remain to be accurately identified, but viable explanations relate **to muscular strength, proprioceptive balance, and flexibility improvement**, which overall improve physical preparedness for sport participation.
Ekstrand, J. (2016).	**The average cost to the club due to injuries is around €20 million a season**. We need to **work together in multi-team/multi-league studies** to increase our ability to answer important, practical questions
Charlton et al. (2017).	There **is limited evidence from level 2 and 3 studies indicating exercise therapy may reduce the incidence and hazard risk** of sustaining a **groin injury** in athletes. There is strong evidence from level 4 studies indicating exercise therapy is beneficial as a treatment for groin injury in athletes in terms of symptom remission, return to sport **and recurrence outcomes**
Taylor et al. (2017).	This is the first study to use the Doha agreement classification system and highlights the prevalence **of adductor-related groin pain** and that often multiple clinical entities contribute to an athlete's groin pain. Consequently, **prevention programs should be implemented with these factors in mind**
Krommes et al. (2017).	Exercise-intensity of **six investigated exercises** in the **Hölmich groin injury prevention program**, except cross-county skiing, is sufficient to be considered **strength-training** for specific muscle groups in and around the groin region.
Evans et al. (2018).	Reduced severity of lumbo-pelvic-hip injuries in professional **Rugby Union** players following **tailored preventative programmes.**
Loose et al. (2018).	The basic knowledge of prevention and injuries is sufficient in elite football, but **the transfer from theoretical knowledge to practical routine is suboptimal. Communication between players, coaches, doctors, and physiotherapist is essential.**

IPP: Injury Prevention Programmes; Exc Th: Exercise Therapy

As demonstrated in Table 26, injury prevention programmes are being encouraged. Further, the studies defining injuries in specific groups can give an awareness of the basic factors regarding prevention strategies e.g. Eirale et al. (2014) – goalkeepers in football; Ekstrand et al. (2018) - coaches' leadership styles and injuries in elite football teams; Trentacosta et al. (2017) - dancers and Larruskain et al. (2018)- elite male and female football players:

11c. FIFA 11 / FIFA 11+

Slide 290

One of the most utilised injury prevention programmes is that of FIFA 11+ (Thorborg et al., 2017) (Slide 290). The injury-preventing effect of this programme compared with controls was shown in football to reduce football injuries by 39%. Amongst other pathologies, this included prevention strategies of the hip and groin (Thorborg et al., 2017).

Table 27: FIFA 11 and FIFA 11+ for Prevention

Author	Title	Outcome
Rossler et al. (2016)	A new injury prevention programme for children's football--FIFA 11+ kids--can improve motor performance: A cluster-randomised controlled trial.	Study evaluated the effects of a newly developed **injury prevention programme** for children's football ("FIFA 11+ Kids") **on motor performance in 7-12-year-old children.** **Possibly beneficial effects** were found in Y-balance, drop jump reactive strength index, drop jump height, countermovement jump, standing long jump, slalom dribble and wall volley test. Most effects in all parameters were small, but **slight improvements in motor performance** may potentially contribute to a reduction of injury risk.
O'Brien and Finch, (2016).	Injury prevention exercise programmes in professional youth soccer: Understanding the perceptions of programme deliverers.	**FIFA 11+ needs modification for use in professional youth soccer teams.**
Ayala et al. (2017).	Acute effects of 3 neuromuscular warm-up strategies on several physical performance measures in football players	**Neither the FIFA 11+ nor the Harmoknee routines appear to be preferable to dynamic warm-up routines** currently performed by most football players prior to training sessions and matches.
Gomes et al. (2017).	Effects of the FIFA 11 training program on injury prevention and performance in football players: A systematic review and meta-analysis.	**FIFA 11** can be considered as a tool to **reduce the risk of injury.** It may **improve dynamic balance and agility** and can be considered for inclusion in the training of football players.
O'Brien et al. (2017).	The delivery of injury prevention exercise programmes in professional youth soccer: Comparison to the FIFA 11.	**The delivery and content of IPEP requires considerable tailoring.** Recognising this, will inform the development of improved, context-specific injury prevention exercise programmes, along with corresponding strategies to enhance their implementation.
Gatterer et al. (2018).	The "FIFA 11+" injury prevention program improves body stability in child (10 year old) soccer players.	The **FIFA 11+** programme **might contribute to injury prevention and possibly to better soccer performance as well.** This might especially apply if the programme is performed over a longer period and/or with more weekly training sessions
Hammami et al. (2018).	The efficacy and characteristics of warm-up and re-warm-up practices in soccer players: A systematic review	This review demonstrated that a static stretching WU reduced acute subsequent performance, while **WU activities that include dynamic stretching, PAP-based exercises, and the FIFA 11+ can elicit positive effects in soccer players.** **The FIFA 11+ WU also significantly increases strength, jump, speed and explosive performances** (changes from 1% to 20%) The efficacy of an active RWU during half-time is also justified.

Pomares-Noguera et al. (2018).	Training effects of the FIFA 11+ kids on physical performance in youth football players: A randomized control trial	The main findings of this study suggest that just **4 weeks of implementation of the FIFA 11+ kids produced improved physical performance** compared with traditional warm-up routines in youth soccer players.
Weber-Spickschen et al. (2018).	Injury prevention in amateur football with FIFA 11+ : What is implemented on the football pitch?	The prevention program **FIFA 11+** is seen by coaches in recreational and amateur football as an **effective tool to prevent injury. Implementation on the football pitch is not as frequent as the evidence-based recommendations in the training concept**.

WU: Warm Up; RWU: Re-Warm-Up; PAP: Post-Activation Potentiation-based exercises

The coaches, fitness coaches and physiotherapists of professional youth teams support the use of injury prevention exercise programmes, but enhancing their impact requires tailoring of programme content, along with adequate delivery and support at multiple levels as is demonstrated in Table 27.

11d. Prevention Strategies

McCall et al. (2015a) explained the perceptions and practices of injury prevention strategies undertaken by the physicians from the 32 participating national teams at the FIFA 2014 World Cup. Their outcome showed that although many of the National football teams' injury prevention perceptions and practices follow a coherent approach, there remained a lack of consistent research findings to support some of these perceptions and practices.

Slide 291

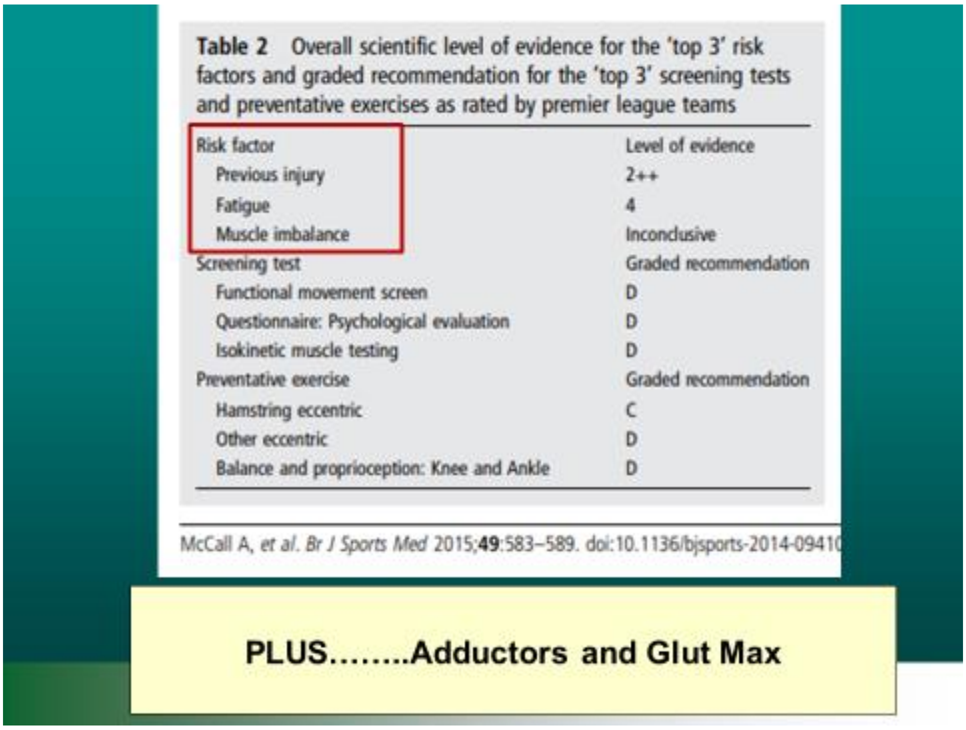
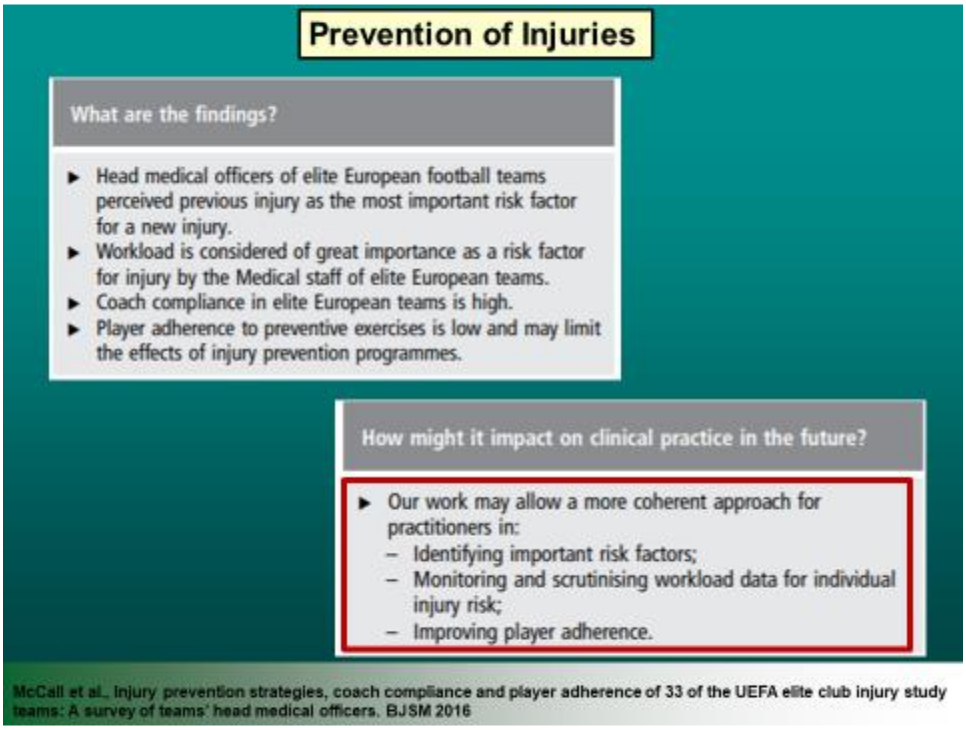


Table 2 Overall scientific level of evidence for the 'top 3' risk factors and graded recommendation for the 'top 3' screening tests and preventative exercises as rated by premier league teams

Risk factor	Level of evidence
Previous injury	2++
Fatigue	4
Muscle imbalance	Inconclusive
Screening test	**Graded recommendation**
Functional movement screen	D
Questionnaire: Psychological evaluation	D
Isokinetic muscle testing	D
Preventative exercise	**Graded recommendation**
Hamstring eccentric	C
Other eccentric	D
Balance and proprioception: Knee and Ankle	D

The pertinent findings from another study by McCall et al. (2015b) determined the scientific level of evidence of the specific injury risk factors for professional football players and provided a graded recommendation for use of screening tests to identify injury risk in professional football players and aid injury prevention (Slide 291). Further investigation was required by researchers to validate or refute the perceptions and practices used in the practical setting to close the gap between science and practice. Although their study was very insightful and specific, I personally feel that there is more pertinent information that could have been included i.e. Adductor strengthening (concentric and eccentric), maintenance of all range of movement required in a specific sport, Gluteus Maximus strengthening as well as Gluteus Medius and Minimus functional stabilising.

Slide 292

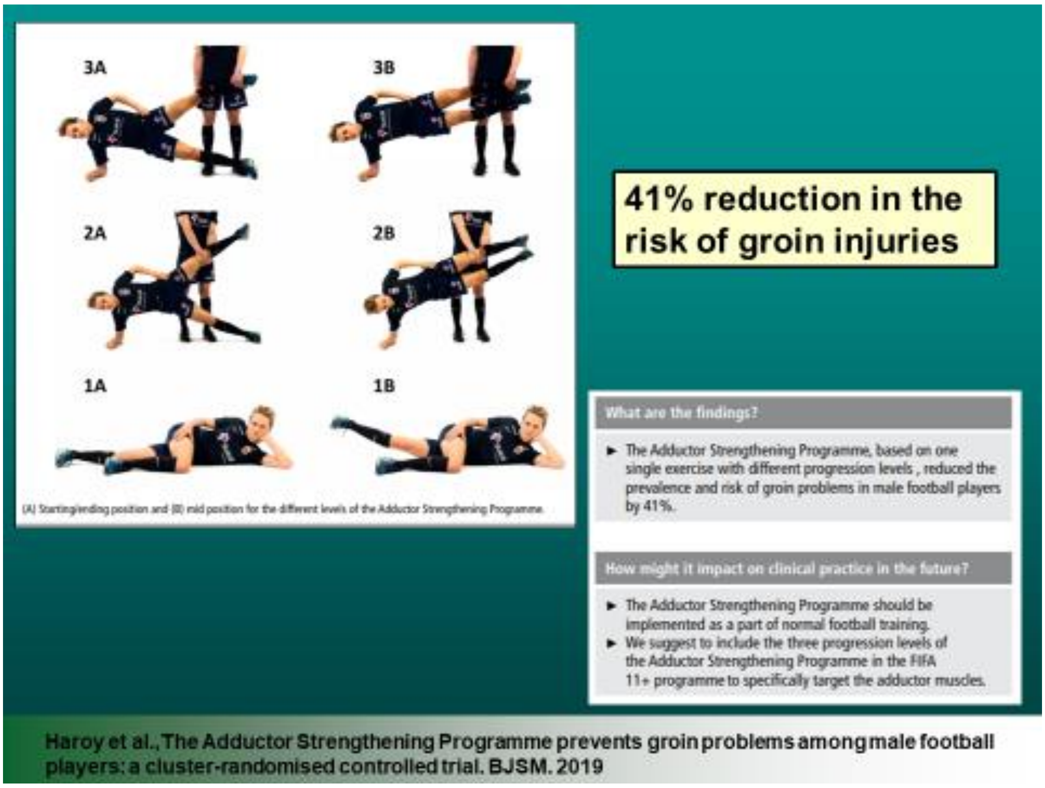


A survey incorporating the team's head medical officers of 33 UEFA Elite Club injuries was undertaken by McCall et al. (2016). They wanted to obtain evidence of the injury prevention strategies, coach compliance and player adherence of these elite clubs. Their findings are demonstrated in Slide 292. This approach is imperative, as one needs to highlight what is actually happening in the sports arena and not just produce more studies that are not practically applicable. This study highlights the fact that injury prevention strategies can only be successful with the coach compliance and player adherence to the exercises. Whatman et al. (2018), re-affirms that appropriate coach attitudes to injury are important for facilitating the development of safe responses to injury and ensuring the adoption of injury prevention strategies that would benefit sports participation and general health.

A respectful and trusting relationship with the coach who agrees to the prevention strategies is of great importance and was emphasised by White et al. (2014), who claimed that the extent to which the coaches undertake this role depended upon their attitudes about injury prevention, their perceptions of what the other coaches usually do and their own beliefs about how much control they have in delivering such programmes, with junior coaches being most receptive. I agree with him that future coach education could include role modelling by prominent coaches so that more community-level coaches are aware that this is a behaviour that many coaches can, and do, engage in. I do believe that the clinician in the first place has great influence in obtaining the trust of the coach and thus possible consequential implementation of this strategy.

Further, educating the coaches is a good introduction e.g. with my work at Ghana’s Right to Dream Soccer Academy, I presented a workshop to coaches regarding decreasing work load to reduce pathologies at the symphysis pubis / groin. Similarly, I presented workshops / presentations to coaches at Ubuntu Soccer Academy, Afrika Tikkun and others, on prevention strategies and have been well received. I have discovered that the coach takes cognisance of my presentations if they are titled with the wording “Prevention of Injuries and Enhance Performance”. There are studies to validate this claim and acceptance and implementation of the strategies are more likely to be undertaken if the performance may improve (Starling, 2019).

Slide 293



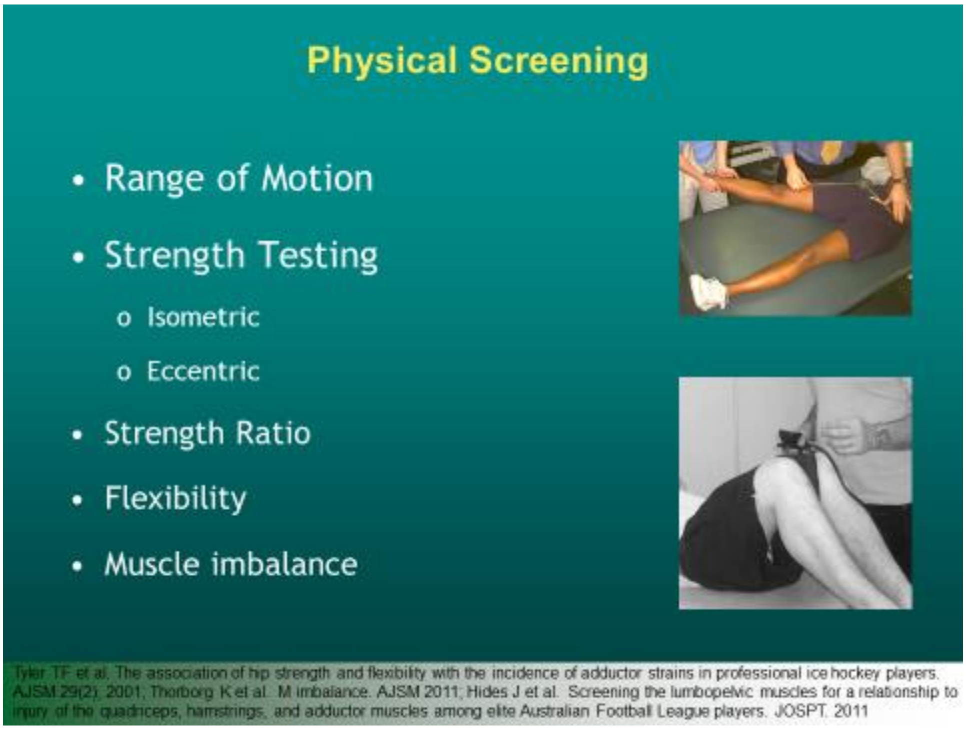
A good example of prevention of groin problems amongst male football payers was demonstrated by Haroy et al. (2019), where they had a 41% reduction in the risk of developing groin injuries by applying the specific adductor strengthening programme (Slide 293). I have found the Copenhagen Hip Adduction Exercise to be most useful and would highly recommend that the clinician should take cognisance of this regime, which has been totally underestimated in the past.

11e. Pre-participation Screening

The aim of musculoskeletal screening is to assess recovery from any previous injury and also the presence of any suspected risk factors for future injury. There is an ongoing debate as to whether it should be mandatory that athletes involved in high risk sports such as ice hockey, football and rugby undertake a screening evaluation and the usefulness thereof to predict injuries. Practically, this has been, and is being, undertaken internationally using different protocols and has been most successful (anecdotal evidence). Unfortunately, it has not always been converted from the practical applicability of the screening to evidence based medicine. Further, different screening tools have been highlighted in studies e.g. Dallinga et al. (2012).

Many years ago, Brukner et al. (2004) described the positive rationale for clinicians to perform pre-participation screening. This was done regularly in Australian sports and the only limitation was financial and time constraints. This was a comprehensive medical screening which could be adapted, depending on the individual and the sport played. More recently, Mosler et al. (2018) explained that the association between previous groin injuries and eccentric adduction strength with the risk of groin injuries was not strong enough to identify an "at-risk" individual. Therefore, according to them, musculoskeletal screening tests was not useful to dictate individualized prevention strategies and bony hip morphology was not associated with the risk of groin injuries. I do not believe that these are grounds for aborting pre-participation screening.

Slide 294



Regular screening of players has been used in team-sport settings to assess training adaptations, readiness to train, fatigue, impact of match and injury-risk profile (Slide 294). There is considerable support for specific protocols. However, debate remains as to whether these protocols actually assess readiness or injury risk. Clinicians need to be aware of these limitations and ensure that all assessments are executed in a reliable, valid manner (Burgess, 2017).

Previously, Whittaker et al. (2015) recommended that investigators focus on developing and evaluating pre-participation screening and groin injury prevention programmes through high-quality randomised controlled trials targeting athletes at greater risk of injury. A narrative review on how one moves from risk factor identification to injury pattern recognition acknowledged that sports injuries are complex emergent phenomena produced by interactions among different units which may produce risk profile that prompt the emerging pattern of injury (Bittencourt et al., 2016). This approach considers an interconnected and multidirectional interaction between all factors, which embrace the complex nature of the sports injury.

Steve Wright, Physiotherapist from Southampton Football Club discussed screening (Football Medical Association Conference on Tackling the Hip and Groin, Midlands, England, UK, 2016.) and spoke of three major points:

- *"Screening should account for previous history, range of motion and strength.*

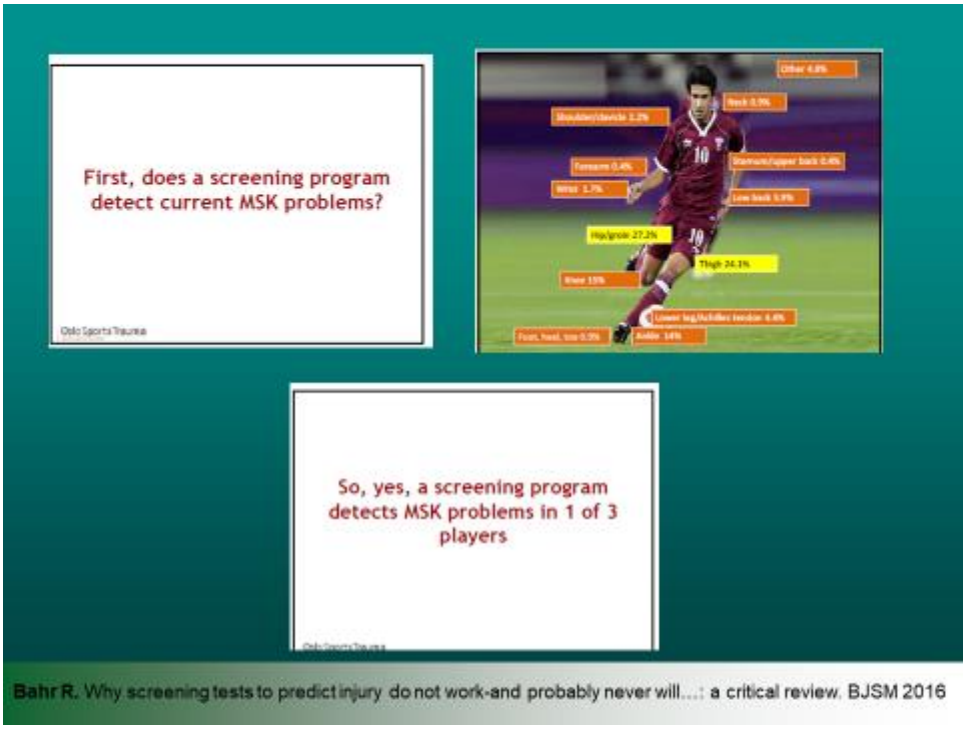
- *Emerging evidence that predictable hip dysfunction seen in groin pain was dissociation of the femur and trunk lumbo-pelvic hip stability.*

- *Early evidence from biomechanical analysis show altered patterns of landing, cutting and change of direction are present in those with groin pain".*

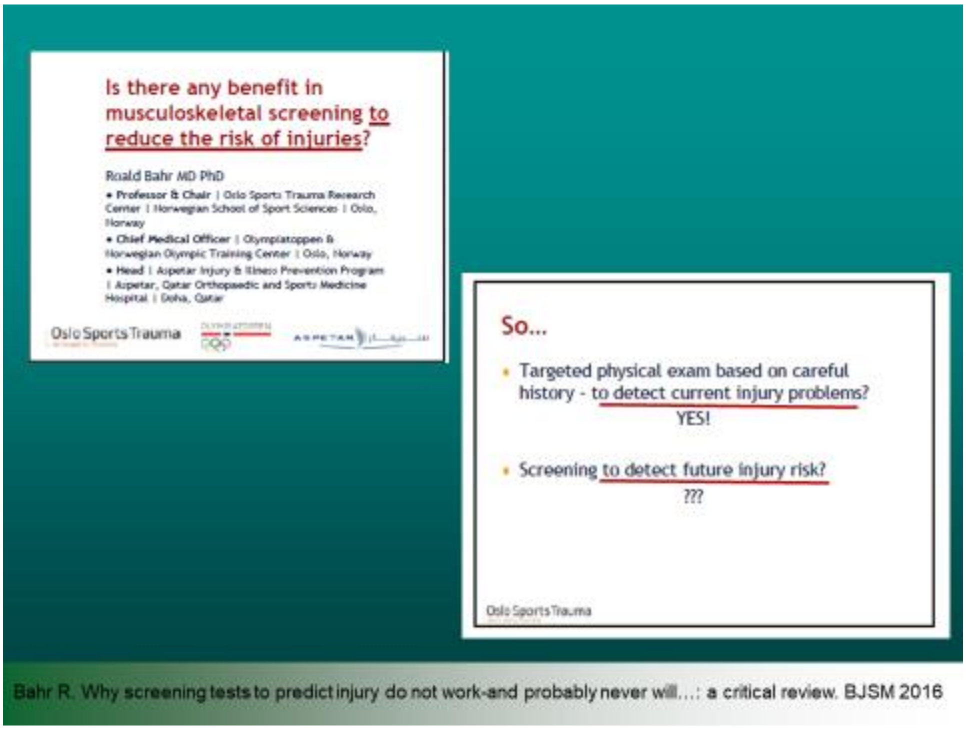
Different screening tools have been occasionally discussed in different sports studies e.g. Cotorro et al. (2014) who explained the fact that hip screening of elite youth tennis players demonstrated that 62% of the athletes have a hip "at-risk" for "FAI" based on physical examination. Although one still does not know when this morphology become symptomatic, I believe a prevention strategy would be beneficial even with asymptomatic morphological changes.

Although Pre-Participation Screening protocols have been widely used over the past years, it has become a "hot" topic recently, due to the fact that Roald Bahr produced a critical review in the BJSM regarding the fact that screening tests to predict injury do not work and probably never will work (Bahr, 2016).

Slide 295



Slide 296



As can be seen from the two slides above (Side 295 and 296), Bahr presented at the Aspetar Conference (First World Conference on Groin Pain in Athletes, Doha, Qatar, 2014.) and demonstrated his strong feelings regarding Pre-Participation Screening and the fact that his studies proved that Pre- Participation Screening does not prevent injuries. Bahr explained that although clinical practitioners and sports practitioners can recommend and implement Pre-Participation Screening, there was no screening test available to predict sports injuries with adequate test properties and no intervention study providing evidence in support for screening for injury risk. He affirmed that while predicting future injury risk through screening tests is unrealistic, a pre-participation examination can serve several other purposes, as outlined in the IOC consensus statement on periodic health evaluation of elite athletes (Ingersoll, 2009). This includes a comprehensive assessment of the athlete’s current health status and it is the entry point for medical care of the athlete. Other potential benefits of regular health examinations include establishing rapport between the medical team and the athlete, reviewing medications and supplements to avoid inadvertent doping, establishing a performance baseline for the athlete in the healthy state, and, in some settings, to satisfy the medico-legal duties of care. The response in the BJSM to this controversial study (Bahr, 2016) was submitted by Hewett, (2016). Although he commended Bahr for this controversial commentary, he felt that there were multiple contradictions and flaws in the logic that must be considered by the readership. He stated that although it may be accurate that injury screening may not be able to predict which individual is going to go on to a subsequent injury, it can clearly be used to identify risk subgroups. He then named many additional positive side effects:

1. Medical/research team engagement with athletes.

2. Athlete education and team awareness.

3. Potential placebo and Hawthorne effects.

4. Objective testing to identify deficits.

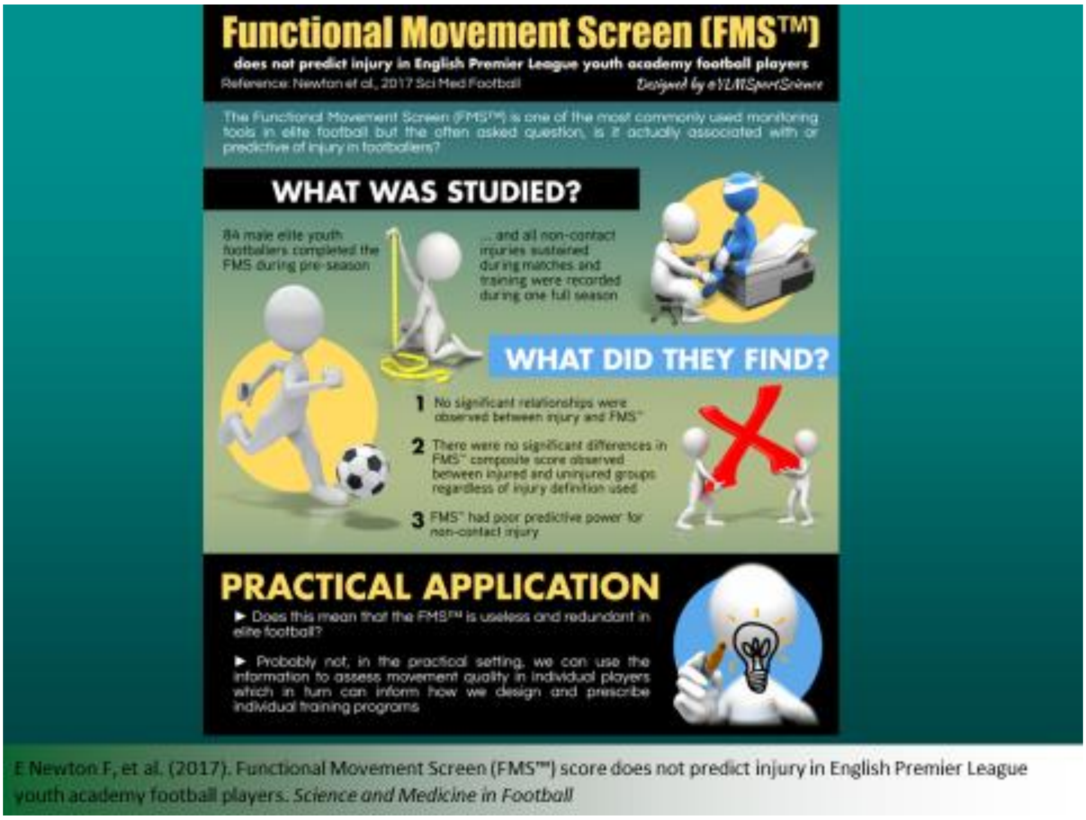
5. Target evidence-based interventions.

6. Enhancement of athlete performance.

From my experience, I have great respect for Pre-Participation Screening as an important component for prevention of injuries e.g. Chapter 3 – Anatomy - regarding adductor strengthening and hamstring injuries.

There is no question in my mind and contrary to Bahr's outcome, I believe that by doing biomechanical functional tests amongst other tests, one can observe potential injury risk. Clearly, more specific studies are required to validate this anecdotal comment.

Slide 297



The Functional Movement Screening has been a commonly used tool for pre-screening in elite sports. However, Moran et al. (2017) found that overall, there were few high-quality studies regarding achieving acceptable levels of inter-rater and intra-rater reliability of composite Functional Movement Screening scores (Slide 297).

However, the Functional Movement Screening may be useful in other ways such as providing useful information to applied practitioners when designing strength-training programs for groups of players they are unfamiliar with, as is often the case at the start of a new season.

Table 28: Pre-Participation Screening

Author	Outcome
Gabbe et al. (2004).	The findings suggest that these **simple, clinical measures of flexibility and ROM** are **reliable and support their use as pre-participation screening tools** for sports participants.
Bardenett et al. (2015).	The **FMS** may be useful for recognizing deficiency in certain movements, however this data suggests that **it should not be used for overall prediction of injury** in high school athletes throughout the course of a season.
Horobin and Thawley. (2015)	**QASLS** (3 repetitions of the SLS test on each limb) **is an effective and reliable tool** for predicting injuries in athletes and as such can be used as a **NM screening** method as part of an injury prevention.

Jacobsson and Timpka, (2015).	A **more distinct classification of prevention supports a specific and cost-effective planning** and translation of sports injury prevention and safety promotion adjusted to the delivery settings, various injury types, and different groups of athletes. a). **Sports Medical care** context: the clinical classification is based on **pathological findings** (observation of pathology in clinical examinations) b). **Sports health and safety** promotion context and the epidemiological classification is based on **risk indicators** identified in epidemiological studies of athlete populations
Mischiati et al. (2015).	The **movement control tests** of The Foundation Matrix had **acceptable reliability** between raters and within raters on different days. Recommendations have been made for refining the criteria and number of repetitions of some tests to improve reliability.
Soomro et al. (2016).	Compared with normative practices or control, **IPPs significantly reduced IRRs** in adolescent team sport contexts.
Chimera et al. (2016)	FMS movement patterns were affected by lower extremity ROM and core function. **Clinicians should consider lower FMS performance as indicative of underlying issues in ROM and core function.**
Hides and Stanton (2017).	**Combining size measurements of the multifidus and QL muscles improved predictive power** in professional football players. This information may have clinical implications for injury screening and prevention.
Marques et al. (2017).	**High-performance young soccer players (14 – 20 years) have important functional deficits**, especially in tasks involving deep squat and trunk stability, as well as high prevalence of asymmetry between right and left body side. **This was demonstrated on the FMS testing battery.**
Moran et al. (2017).	**The strength of association between FMS composite scores and subsequent injury does not support its use as an injury prediction tool.**
Smith et al. (2017).	**FMS results should be interpreted cautiously** with attention to the **asymmetries identified during the screen**, regardless of the composite score. **Multiple screening tests should be used** in order to provide a comprehensive picture of the adolescent athlete.
Bunn et al. (2019).	**Individuals classified as "high risk" by FMS are 51% more likely to be affected by injury** than those classified as having low risk, **but the level of evidence is very low.**

FMS: Functional Movement Screen; Qualitative Assessment Tool (QASLS); SLS: Single Leg Squat; IPP: Injury Prevention Programme; IRR: Injury Rate Ratio; QL: Quadratus Lumborum.

As one can see from Table 28, there are conflicting opinions for predicting injuries. Most importantly, from all these studies, is the fact that there is no one single "recipe" for screening. Although some of the above studies do show positive findings for predicting possible injuries, there is no one size fits all. Further, these studies were not specific to preventing groin and hip injuries. Future research is needed in this area. However, I believe that each clinician should devised a screening protocol, based on their in-depth knowledge, for each particular sport and the specific requirements demanded.

Bird and Markwick, (2016) declared that assessment of sport-specific movement demands through musculoskeletal screening and functional performance testing was essential for rehabilitation professionals to determine movement competency during performance of fundamental movements related to basketball performance. In my opinion this would apply to all sports although the functional testing may differ somewhat. This is particularly the case in young athletes who represent a unique population due to their developing musculoskeletal and neuromuscular systems and need to undergo pre-participation musculoskeletal screening for identification of movement limitations. This approach should assist the clinician in identifying injury risk and also be useful at the end of rehabilitation in determining readiness to return to sport models.

As has been referred to in Chapter 8 – Rehabilitation and Chapter 10 – Risk factors, prevention strategies are well documented in a number of studies e.g. deficits in hip muscle strength which may influence hip pain. Kloskowska et al., (2016) showed the number of significant movement and muscle function associations observed in athletes both prior to and following the onset of Sports Related Groin Pain. They suggested that in screening programmes the main focus should be to address hip adductor weakness and knee flexor strength deficits, as they may be risk factors for Sports Related Groin Pain and should be implemented in the prevention and rehabilitation of athletes with Sports Related Groin Pain.

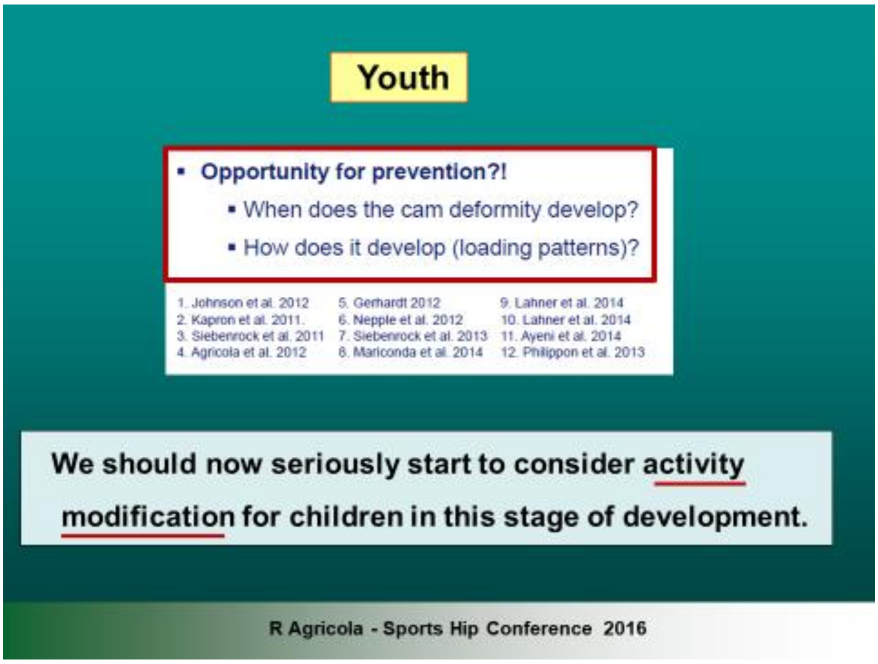
11f. Youth

The risk for hip and groin injuries has been demonstrated to be 6 times more likely in youth Australian Football League players compared to their peers (Gabbe et al., 2010). Thus regarding youth and prevention of groin and hip pain, all clinicians should use the basic concepts and principles from the IOC consensus statement on youth athletic development (Bergeron et al., 2015). Above all, they need to support the promotion of evidence-informed perspectives to coaches, the athlete entourage, medical providers and administrators involved in youth sports. This is not only to ensure an enjoyable, safe, healthy and sustainable experience for all participants, but to have a well-structured prevention strategy for each individual.

- **Youth: Cam (Camshaft) Morphology**

When discussing control of load as a prevention strategy, it is imperative that the hip morphologies and possible FAIS are discussed, particularly in relation to the impact this has on youth in sport. Abnormal hip morphology is postulated to be a strong predictor in the development of hip OA. Strategies need to be developed to prevent these hip morphologies becoming symptomatic (FAIS) and the possibility of its progression to OA (Griffin et al., 2016).

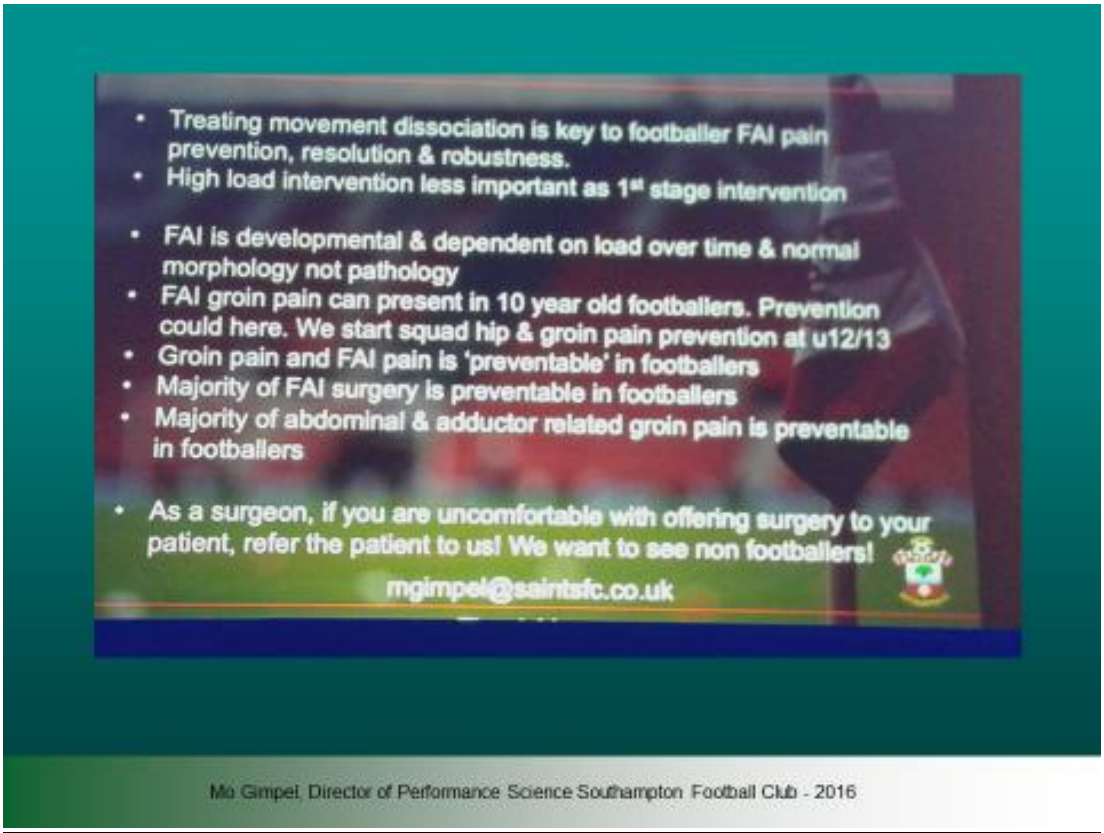
Slide 298



This was strongly recommended at a Conference in London (Warwick Sports Hip Meeting, National Football Centre, St George's Park, Burton-on-Trent, Staffordshire, UK, 2016) where Agricola demonstrated the importance of activity modification for children in their stage of development (Slide 298).

The debate ensues as to whether the development of Cam (or pincer morphology) is secondary to excessive physical activity or a combination of a vulnerable physis and a set level of physical activity (de Silva et al., 2016).

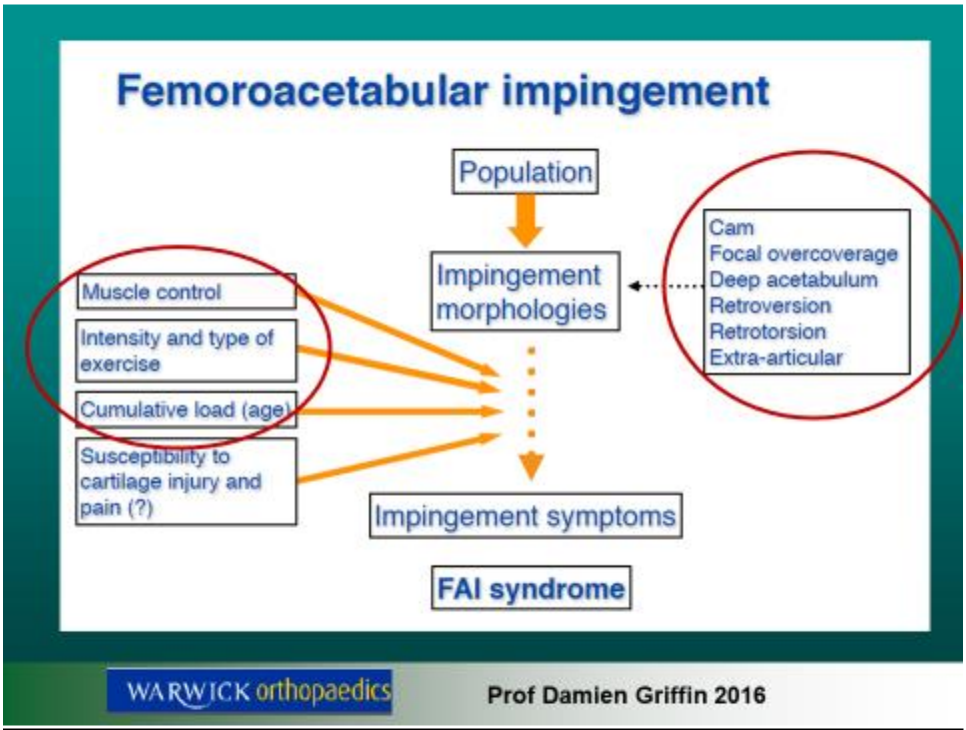
Slide 299



Slide 299 clearly shows the belief that groin pain and "FAI" is preventable in footballers, as well as FAI surgery being avoidable (Gimpel, Warwick Hip Conference, St George's Park, Burton-on-Trent, Staffordshire, UK, 2016). It is interesting that his belief was that treating movement dissociation was key to footballer FAI S prevention and resolution and high load intervention was less important than movement dissociation as a first stage intervention. I don't necessarily agree with this statement as there are more permutations involved. My belief is that identifying any mal-adaptations that may be a risk factor for an athlete and consideration of the load transfer between the trunk and lower extremity i.e. optimal alignment, optimal biomechanics and optimal motor control is the basic prevention strategy. The restriction or malfunction may then be identified, as well as the anticipation of where the transfer of load is going to fail.

Further, Gimpel stated that the majority of abdominal and adductor-related groin pain are preventable in footballers and they (Southampton Football Club) are currently constructing a study accordingly.

Slide 300



Cumulative load, particularly in the young athlete, requires intense scrutiny. However, as Damien Griffin showed in his presentation (Warwick Sports Hip Meeting, National Football Centre, St George's Park, Burton-on-Trent, Staffordshire, UK, 2016), in order to prevent the morphological changes, there are a number of factors that we, as clinicians, have control over, such a muscle control, intensity and type of exercise as well as cumulative load (Slide 300). With collaboration of the coach / manager, the intensity and type of exercise and cumulative load can be monitored or altered.

- **Cam Morphology and implications (OA Prevention)**

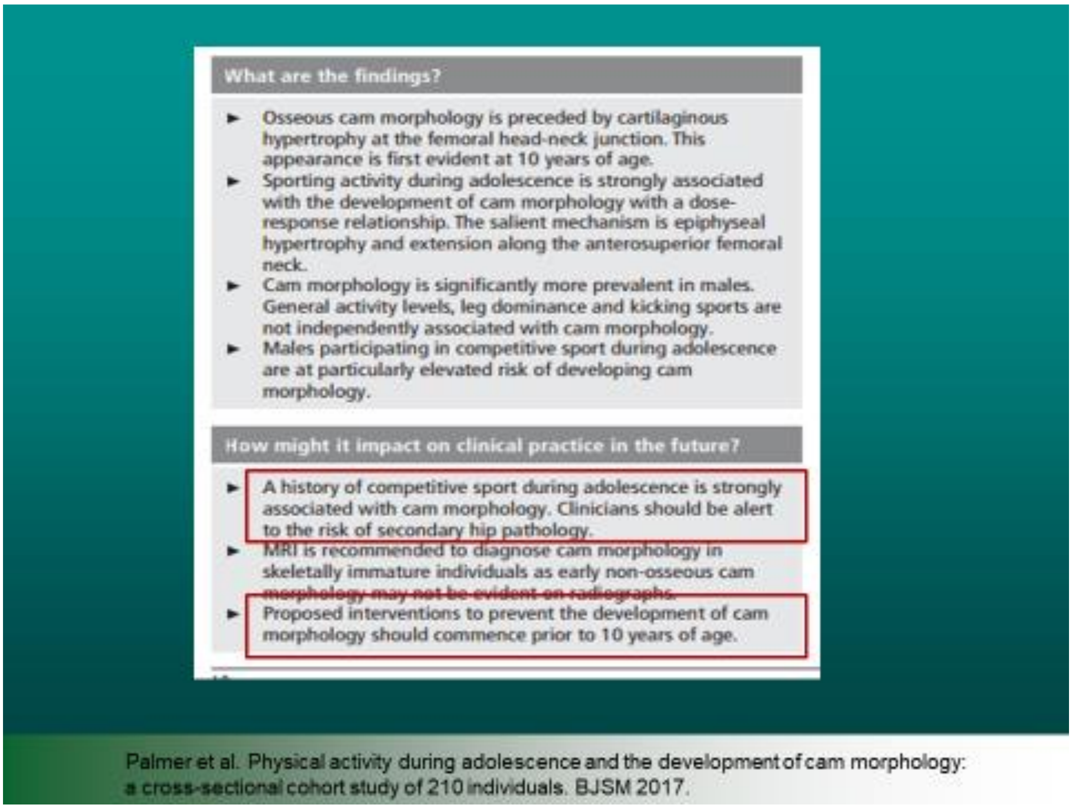
Regarding prevention of groin and hip problems and having discussed Cam and load, one needs to see the bigger picture regarding the implication of the hip morphology and the possible resultant implications of FAIS and OA. This has been mentioned a number of times in this thesis. So the dilemma which is currently a very prominent topic internationally, is that of prevention of the cam or pincer morphology in the first place in order to prevent possible symptoms of FAIS and then possible consequential OA.

Cakic and Patricios (2014) discussed hip morphology and whether the sports physician should prevent or intervene. They explained that typically, the patient is aware of limited hip mobility, however, symptoms of pain only appear later. Owing to this lack of pain, which would act as an ‘alarm system’, significant damage to the hip joint can occur before a positive impingement sign becomes evident. As hip morphology is a hip disorder presenting mainly in young adults often without positive clinical findings, they hypothesised that if left untreated, it may lead to significant morbidity in the form of early arthritis. Thus early recognition may allow practitioners to more effectively counsel young active patients in regard to a non-operative strategy such as modification of activity and exercise training with the goal to prevent further progression of the condition.

As previously discussed, a number of studies show that limited hip range of motion is associated with early OA changes in adolescent athletes e.g. Wyles et al. (2017). Young athletes with limited range of motion of the hip showed increased progressive degenerative changes on MRI and radiographs compared with matched controls and although the majority were asymptomatic, those with features of “FAI” had radiographic findings consistent with early OA. Thus aggressive screening and counselling of young active patients may be helpful to prevent hip OA in those with hip morphology. Whether this is due to a decrease in hip range of motion remains debatable.

Pun (2016) explained that although prior studies demonstrated that a large portion of arthritic hips had underlying dysplasia or “FAI”, it remains unknown how many hips with radiographic signs of dysplasia or “FAI” stay asymptomatic and continue to function into old age. They could not conclude that dysplasia and “FAI” were not associated with the development of OA overall. They declared that there are additional genetic, biochemical and behavioural factors that affect whether hip OA becomes symptomatic. Dysplastic and Cam or pincer morphology are spectra of deformities that are modulated by many non-anatomical factors such as genetics, activity level, and age, making it difficult to predict which hips with dysplasia or hip morphologies will eventually become symptomatic and develop OA.

Slide 301



Intense sporting activity during adolescence is associated with Cam morphology secondary to epiphyseal hypertrophy and extension along the antero-superior femoral neck. Cam morphology is first evident as cartilaginous hypertrophy at age 10 years and males participating in high-level sports during adolescence are at a particularly elevated risk of developing Cam morphology and secondary hip pathology (Palmer et al., 2017). (Slide 301). They proposed that interventions to prevent the development of Cam morphology should commence prior to ten years of age.

Pertinent studies regarding the prevalence of Cam and pincer morphology and their association with the development of hip OA include Van Klij et al. (2018) - Cam morphology has been associated with development of hip OA, but the association between pincer morphology and hip OA was much less clear; Diamond et al. (2018) - individuals with FAIS exhibit altered biomechanics during step ascent and recommended that interventions targeting strength measurement, including agonist/antagonist ratios, may be relevant for clinical management of FAI and as a prevention strategy.

The dilemma is at what point do these biomechanical mal-adaptations become apparent? And is there a possibility of identifying the start of these symptoms before FAIS becomes a problem?

As there are a number of tests for groin and hip pain (specified in Chapter 5 - Tests), some may be useful in identifying cam or pincer morphology / potential FAIS and thus implementing a prevention strategy. Casartelli et al. (2018) discussed youth ice hockey players and the use of the FADIR test and concluded that this test was inadequate for screening Cam and pincer morphology in youth ice hockey players without diagnosed hip disorders because of the large number of false positive test outcomes. As we continue to evaluate the capacity to screen for FAIS, there may be more consensus, but as of now (2019), the FADIR test may be used as a screening tool with caution and particularly clinicians should take into consideration the patient's additional clinical signs and subjective complaints.

Conclusion – Cam Morphology

There are significant knowledge gaps between clinical practice and research on FAIS. In elite sports one needs to understand this anatomical adaptive formation and thus have a prevention strategy. From my experience, I would advocate that the emphasis was on hip and lumbo-pelvic stabilization, correction of hip muscle imbalance, biomechanical control, and sport-specific functional progression. This should be a mandatory procedure for training all athletes in all sports as a preventative measure.

It would be beneficial to have more studies on groin and hip prevention of injuries in the youth sporting population. Nonetheless, the clinician should take cognisance of all the prevention studies and be particularly mindful when dealing with youth sports and prevention of groin and hip injuries.

11g. Psycho-Social Factors

Even though it is difficult to provide EBM, psychosocial factors in the sports domain is of utmost importance (Johnson and Ivarsson, 2017). The following points were highlighted which may have an effect on the prediction and prevention of sports injuries. Amongst these points were the following:

- "Psychosocial variables influence injury risk among athletes.
- Changes in stress seem to predict injury incidence in sport.

- Psycho-physiological as well as sociocultural factors can influence the risk of overuse injury.
- **Injury prevention programs based on combinations of neurophysiological and neuropsychological exercises are warranted"**

All clinicians working with sports men and women, of all ages, should take note of these points and it is recommended that apart from injury management, they would be useful for an interdisciplinary injury prevention programmes based on a combination of physiological and psychological interventions.

Ivarsson et al. (2017), Olmedilla-Zafra et al. (2017) and Tranaeus et al. (2015), re-affirmed the effectiveness of stress management and awareness of psychosocial variables to reduce the incidence of sports injuries amongst athletes. Prevention of re-injury is also a factor which has individual psychological implications.

Slide 302

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Model stage	TRIPP	van Mechelen et al 4 stage approach [1]
1	Injury surveillance	Establish extent of the problem
2	Establish aetiology and mechanisms of injury	Establish aetiology and mechanisms of injury
3	Develop preventive measures	Introduce preventive measures
4	"Ideal conditions"/scientific evaluation	Assess their effectiveness by repeating stage 1
5	Describe intervention context to inform implementation strategies	
6	Evaluate effectiveness of preventive measures in implementation context	

An excellent injury prevention protocol, although not specifically for groin and hips, was shown in a recent study (Emery and Parsenon, 2019), whereby they demonstrated the possibility of translating research into injury prevention practice (Slide 302). They explained that neuromuscular training warm-up programs including strength, balance, aerobic, and agility components can reduce the risk of musculoskeletal injuries at least 35% in team sport and other youth sport settings. This should be evaluated and practiced regarding groin and hip injuries.

Conclusion - Prevention of Hip and Groin Injuries

The protection of an athlete's health and preventing injuries and illnesses in sport are top priorities for all sportsmen and women, as well as all personnel involved with sport. This was highlighted by the IOC and its Medical Commission (Engebretsen et al., 2014). However, to date there is still a need for quality research designs confirming the clinical impact of existing injury prevention interventions for all athletes, including pre-elite athletes (Smythe et al., 2019). In particular, there needs to be more research on prevention of hip and groin injuries and more so in the young athlete. The risk for hip and groin injuries has been demonstrated to be 6 times more likely in youth Australian Football League players compared to their peers (Gabbe et al., 2010). As has been clearly demonstrated in previous chapters, there are studies that show the potential problems in the young sportsman / woman (particularly such as FAIS). The BJSM Blog (Perera and Thorborg, 2017) have an apt title – "What's 'groin' on – groin injury prevention and management" and explain that evidence for groin injury prevention has been limited. Although Thorborg et al (2017) claimed that hip and groin injury can be reduced by up to 40% using the FIFA 11+ programme, they stated that these results were based upon only two studies with heterogenic populations.

Slide 303

Slide 303 shows an overview of different areas to take into consideration when organising a prevention procedure for hip and groin problems. As has been stated previously, knowledge of the entire kinetic chain and its interconnectedness is the foundation for a successful prevention strategy. Clinicians need to be aware of the risk factors pertaining to the groin and hip areas, such as muscle weakness and imbalances, neuro-motor control, inflexibility and many others (as has been described). Thus with regard to the groin and hip, I believe it is imperative to identify all the risk factors and the mal-adaptations and subsequently organise a prevention training programme specific to the pelvic / hip area accordingly, bearing in mind the individual athlete's requirements for his / her particular sport. As functional deficiencies and potential for injuries are widespread in many athletes, I believe that all sports men and women, regardless of any risk factors prevalent, should have a thorough hip and groin strength/ neuro-motor control training programme incorporated into their pre-season and in season training. Thus, as mentioned previously, it would be a prerequisite that they would all be undertaking this programme (as was the case with all athletes with which I have been involved).

I propose that prevention of hip and groin injuries is highly feasible. With the multitude of studies being published on an ongoing basis regarding the management of all these frequently prevalent groin and hip problems, one can see the value of undertaking a prevention programme for all athletes. In elite sports where “quick fix” and time is critical, this is mostly not the case. It is up to the sports clinician to educate all parties concerned regarding the relevance of this crucial strategy. One can also take into consideration the fact that sports injury prevention will only be achieved if research efforts are directed towards understanding the implementation context for injury prevention, as well as continuing to build the evidence base for their efficacy and effectiveness of interventions (Finch, 2006). The difficulties and actual implementation and compliance of all parties should be recognised and dealt with accordingly.

Chapter 12. Conclusion: Groin and Hips Complexities

Groin and hip pain is common in athletes who participate in multidirectional sports such as adult, male football players (Mosler et al., 2018; Thorborg et al., 2017) and is frequently reported. However, this often debilitating injury in athletes has been an area which has been under-researched and managed over the past years. From my work in elite sport, I have personally experienced many of the difficulties which are encountered by the medical personnel, which is further compounded by the extreme time pressure for return to play of the athlete.

Unfortunately, the success of preventative strategies which is discussed during my career with colleagues, is not firmly entrenched in evidence based medicine and thus often there is no recognition of these strategies. The medical personnel involved in elite sports are mostly too busy to undertake studies to validate their findings. As stated previously in this thesis, the hamstring tests which I created is finally being researched, whereas the helpful PNF test remains anecdotal. Until one can verify this (make it objective and not subjective), the manoeuvre will be used sparingly. Thus it would be most useful if clinicians out in the field could manage to turn their very practical, applicable and useful strategies into evidence based medicine. Only then will everyone take cognisance of their specific strategy and use it accordingly.

Specific considerations

i. I discuss repeatedly in all my presentations, regardless of the audience, that an in-depth knowledge of **anatomy, functional anatomy**, the **biomechanics** and the resultant possible consequences of any **weaknesses or mal-adaptations**, may help improve prevention and management strategies of groin and hip pathologies.

ii. A comprehensive understanding of **specific muscles around the pelvis** is helpful to understand the functionality, which can be complicated by the different demands imposed by different sports (Serner et al., 2016; Serner et al., 2018).
In my work first with Super 14 Rugby and then Premier League Football, I
was very aware of the weakness of the **adductor muscles**. I have always implemented a specific adductor strengthening programme for all the rugby players and it is positive to see the changes in the past few years in Premier League where they are now

strengthening these most important muscles and acknowledge that these are major factors for groin and hip pain. This may be due to the increase of the number of adductor studies that verify this factor.

iii. The value of **hip stabilisers** to the entire kinetic chain has been underemphasised in the past. This should be a fundamental prevention policy i.e. strengthening the hip stabilisers, hip strength, progressive loading, balance, neuromuscular control, functional retraining, trunk function and range of motion optimization for each athlete and the sports specific activity (Kemp and Crossley, 2014).

iv. Clinicicians need to consider the effect of anatomical abnormalities / morpholigies which may **impact on different areas of the kinetic chain** and cause resultant pathologies e.g. PFP (Ferber et al.,2011); Lateral ankle sprain (De Ridder et al., 2016); ACL (Boutris et al., 2018; Boykin, 2018); Lumbar spine and Hip pathology (Buckland et al., 2017). Most of these studies state that by strengthening the relevant muscles (definitely including the hip area), prevention is the positive outcome. I have observed much better functionality of knee biomechanics after strengthening the lateral hip stabilisers.

v**. Hip range of motion** and the possible development of groin and hip pain should be taken into account, even if currently there is no definitive information on the specific hip range of motion required in different sports to prevent groin and hip pain in athletes (Tak et al., 2017).

vi. More studies should be undertaken on the importance of **neuromuscular** training for the prevention and management of groin and hip problems. I find this to be the foundation of my management of groin and hip pain.

vii. Since approximately 60% of groin injuries have a more insidious onset, **early detection** and a **sensitive monitoring system/program** is very important (Hölmich, 2017). Examples include the Copenhagen Hip and Groin Outcome Score (HAGOS) (Thorborg et al., 2011) and the Squeeze Test (Esteve et al., 2018).

viii. **Anatomy, functional anatomy and biomechanics** are the cornerstone of prevention and management of all athletes (as discussed by Schache et al.,2000). **Static tests** do not necessarily demonstrate this functionality. It is widely acknowledged that a **battery of tests** is most important. In addition, I propose an increase in the inclusion of **relevant functional tests** which are not currently used with high frequency by specialists as they are considered to be too subjective.

ix. **Ongoing re-assessment** looking for any signs of a potential or recurring groin or hip problem, is most important throughout the season e.g. the adductor squeeze test.

x. The prevalence of hip morphologies and labral tears in asymptomatic subjects is high in certain sports. **Radiological findings** need to be interpreted with caution and in combination with a complete clinical history and examination. (Cheatham et al., 2016; Dahlberg and Englund, 2016; Paajanen et al., 2019; Rankin et al., 2015).
Clinicians may currently be over-reliant on imaging findings when making treatment decisions and imaging should only form one part of the overall assessment (O'Sullivan et al., 2018; Paajanen et al., 2019). **Combining anatomical, histological, clinical and radiological findings**, if possible, would improve the understanding of underlying pathological mechanisms of groin pain in athletes (Klontzas et al., 2017; Weir et al., 2017).

xi. There is an attempt to understand the clinical relevance for the use of **radiological imaging and pubic bone marrow oedema.** My belief is that this mostly asymptomatic pubic bone marrow oedema may be very useful in judging the load management on the pubic bone area, particularly in the young athlete. This early detection and subsequent unloading, may have excellent results in preventing long term hip and groin problems (Bourdon et al. 2017). It would be particularly useful if the MRI could show at **what point this asymptomatic increased uptake of the** pubic bone marrow oedema **becomes symptomatic**. I have asked this question at a number of conferences and the specialist radiologists explain that they are constantly working toward this outcome. Further research is required and I believe this to be a key area for future development. In particular, research into pubic bone marrow oedema as a measure of load and pathology in the **young athlete** is of paramount importance and could be most useful as a prevention strategy (Toslak et al., 2017).

xii. Hip intra-articular pathologies are seen in athletes with and without pain**. Labral tears were identified in up to one in every two athletes without pain**, highlighting a potential discordant relationship between labral tears and pain in athletes. Cartilage defects, bone marrow lesions, herniation pits, hip joint effusion, labral degeneration and ligamentum teres tears were observed in symptomatic and asymptomatic athletes (Heerey et al., 2019). This clearly demonstrates a complex relationship between structural hip conditions identified with imaging and pain in athletes.

xiii. **Cam and Pincer morphologies** have emerged as one of the more commonly recognized intra-articular hip changes. Over 50% of athletes have cam morphology, and over 65% of asymptomatic people, including athletes, have **acetabular labral tears** (O'Sullivan et al., 2018). The most appropriate management for patients with symptomatic hip morphologies (FAIS) is a subject of much debate in sports medicine and orthopaedics. The Warwick Consensus Meeting (2014) proposed three main treatment approaches for patients with FAIS: conservative care, physiotherapy-led rehabilitation or hip surgery. Optimal non-surgical management is not known.
It is my opinion that any athlete who has **Cam or Pincer morphology** should **undergo a prevention exercise protocol.** Further, all athletes, especially young athletes, should undergo education, activity modification and specific strengthening strategies to possibly prevent the development of these morphologies in the first place. This would particularly include off-loading, where necessary.

Thus the goal of treatment for prevention and management of morphological changes / FAIS should be to **optimise hip joint loads**.

xiv. The topic of **youth** has been described in each chapter and is a major concern regarding groin and hip problems, in particular, the possible development of OA after acquiring a Cam or Pincer morphology. An entire thesis could be written on the topic of young athletes and groin and hip problems. In this thesis, each chapter conveys the concerns regarding this issue. The basic management is, as has been shown previously, load management.

xv. The value of **conservative management** of groin and hip varying pathologies has been documented (Dello Iacono et al., 2017; Ishoi et al., 2016; Kemp and Crossley, 2014; Kemp et al., 2018; McAleer et al., 2017; Mellor et al., 2016; Short et al., 2017). However, there are few **specific rehabilitation** strategies for the groin and hip problems reported in the literature. Some studies specify particulars such as the balancing of pelvic integrity and mechanical load through the pelvis (Pizzari et al., 2008) or exercise interventions which target the hip and abdominal musculature (Charlton et al., 2017 and Dello Iacono et al., 2017). Functional exercises related to the specific sports have been of great benefit in my practice. However, there is also a place for targeting specific muscles which effectively increase strength e.g. eccentric training using the Copenhagen Adduction exercise protocol (Ishoi et al., 2016).
The implications with regards to rehabilitation and prevention need further research.

xvi. The management of **Gluteal tendinopathy** is the topic of ongoing discussion and studies (Grimaldi et al., 2015; Mellor et al., 2016). Grimaldi (2017), when discussing conservative management of lateral hip pain where common clinical diagnosis tests have limited validity, felt that nonetheless the future holds promise. The clinician now realises the importance of the hip stabilisers, not only for groin and hip problems, but impacting the entire lower extremity.

xvii. Regarding prevention or treatment of any groin and hip pathology, it is important that the clinician takes into account the athlete's **activities of daily living.** In my experience, it is often the activities of daily living that is causing the hip and groin pain e.g.

sitting incorrectly for long periods (in front of a computer on a daily basis or sitting in a seat with the knees above the hips e.g. long distance driving). The assumption is that the sports activity has caused the pain. Thus activities of daily living should be a basic question and management for all athletes.

xviii. There has been much dissension regarding **surgery o**f groin and hip pathologies over the past years. From my experience and attending many groin and hip conference over the last 13 years, there is definitely more interaction and consensus between the hip surgeons, compared with the groin surgeons, where there is minimal consensus. The difficulty for the medical personnel dealing with elite sport, is that each groin specialist has his / her specific surgical procedure. Unless the pathology is very definitively diagnosed, the athlete may have incorrect surgery and may even have to have further different surgery for a different pathology. I have observed this from years of working in elite sports, including Premier League Football (anecdotal evidence).
Given the complex anatomy, equal intra-articular and extra-articular contribution, and potential for overlap of clinical entities causing groin pain leading to **surgery** in athletes, further studies are required to ascertain the finer details regarding surgical outcomes to best treat this patient population (de Sa et al., 2016). Meanwhile, a comprehensive specific rehabilitation protocol should be undertaken with a time line for surgical intervention.

xix. The anatomical and morphological characteristics may explain why groin pain is **more common in male than female athletes** (Schache et al., 2016). However, there are a limited number of studies in female athletes and further studies focused on female population are needed (Bisciotti et al., 2016).

xx. All the above points are most pertinent for prevention of groin and hip pathologies. However, I feel strongly that without realisation of the absolute importance of the **psychology (and possibly social contextual status),** a prevention protocol will not succeed (Ivarsson et al., 2017; Tranaeus et al., 2015).

Thus prevention of injuries is not simplistic and one should develop a greater appreciation for the underlying complexity of injury prevention concepts. There is a need to continue to improve the methods applied by practitioners working in the sports domain and to have a greater appreciation for the clinical context of the questions we aim to answer and to interpret the results accordingly. As stated very succinctly by McCall et al. (2015), the relation between practice and science can be analysed in two ways: the application of scientific recommendations by practitioners (from science to practice) and the scientific validation of practices by the researchers (from practice to science). Certainly, in the field of groin and hip management, both the clinical fields and academic fields need to learn from each other and work more closely. There are many perceived barriers of sport science research application, including funding, time, coach/player/staff 'buy in' and research questions that may not apply to the setting. Researchers and practitioners may benefit in producing research, ascertaining knowledge and disseminating findings in alternative methods that better align with coaches' needs. In addition, educational strategies that focus on real-world context and promote social interaction between coaches, practitioners, organisational personnel and researchers would likely benefit all stakeholders (Fullagar et al., 2018). I fully concur with these comments and looking back over my career would have appreciated the value of integrating my newfound "discoveries" with science and thus getting more objective evaluation of my practice and possibly more practical application in the field. I personally believe that an evidence based management approach to assessment and treatment is imperative. However, it is equally important to constantly analyse and improve one's practical application, using clinical reasoning in sports medicine and applying the resultant tactics if they prove to be of value, even if subjective. Sharing any successful outcomes with one's colleagues would also be helpful.

In high-performance sport, science and medicine practitioners employ a variety of physical and psychological tests, training and match monitoring, and injury-screening tools for a variety of reasons, mainly to predict performance, identify talented individuals, and flag when an injury will occur (McCall et al., 2017). They proclaim that the ability to "predict" outcomes such as performance, talent or injury, is arguably sport science and medicine's modern-day equivalent of the "Quest for the Holy Grail".

Although it was declared that risk factors are temporal and they vary over time (Verhagen et al., 2018), my belief remains that it is critical to recognise risk factors and organise a prevention strategy accordingly. The clinician should individualise treatment for every athlete and organise a prevention strategy based on a number of factors, including age, gender, the sport, positon within the sport, socio-psychological issues and the demands from the management, including the coach.

In spite of more studies emerging in recent years explaining that screening is not the tool for predicting of injuries, I believe from my experience that specific and adaptable screening, tailored to each individual athlete, remains essential in the efforts to prevent groin and hip pathologies from developing (Holmich et al., 2010 and Krommes et al., 2017). Prevention has been a focus over the past years for all potential pathologies, particularly in respect of the FIFA 11+ programme e.g. Kilic et al. (2018). Previously this was not the case, as described by Börjesson et al. (2015). They stated categorically that there was a need for improvement for prevention strategies. I totally agree with their comment that managers / coaches need to be educated regarding this most important factor and good interactive communication is the key element. This has been imperative to my educational approach to coaches (as well as medical colleagues) over these past years.

The management of young athletes is most significant and decision-making with youth athletes may be complicated, especially when the outcomes of treatment decisions have a high degree of uncertainty. The ethical standards set out in the 2018 IOC consensus statement provide a framework that can help clinicians, and youth athletes and their parents/guardians weigh different treatment options and arrive at the best shared decision (Arden et al., 2018). This is generalised to all injuries but applies to different situations in sports medicine clinical practice such as the groin and hips.

Essentially, this thesis describes the complexities of the groin and hip area and the relevant pathologies. The need for collaboration between clinicians and researchers to ensure validity of clinically meaningful tests and rehabilitation strategies are essential so that they may be used appropriately in future clinical practice. From my work in elite sport, I have little doubt that prevention of most of these injuries is possible, with well informed and ongoing updates of prevention strategies. Communicating with experts working in the field who practically apply specific prevention strategies, as well as constant analysis of one's own positive protocols, is essential. Further, studies on exercise therapy and early surgical intervention are needed to determine the most effective methods of preventing groin injuries in athletes (Sherman et al., 2018).

This thesis represents my professional journey i.e. a quest to find answers to the hip and groin dilemma which has impacted a number of athletes, both elite and recreational. I have sought answers in academic papers and conference presentations, as well as seeking clinical pearls from leading international experts. I have used this knowledge to attempt to provide best quality care for my players. It has been an inspiring journey to learn about the complexities involved with managing hip and groin injuries. There is little doubt that one can make a difference with a prevention protocol for all potential groin and hip pathologies. This has prompted me to give numerous presentations on this topic with colleagues from all sectors of the medical profession, amongst which are orthopaedic surgeons, sports and exercise doctors, sports physicians, sports physiotherapists and Premier League football club medical personnel, as well as coaches in the community. I have learnt so much and want to share this ever evolving evidence based medicine, plus my experience with my colleagues. This thesis, with knowledge coming from all areas explored (as has been discussed), has definitely developed my leadership skills as a clinician and as an educator.

Future research on groin pain in athletes, using established published guidelines to improve study methodological design and reporting, may be productive and a consensus document needs to be drawn up by experts which may provide these guidelines. Essentially, I believe that a panel of experts are required to meld the research findings with the clinician's practical experience. It would be ideal if all this could be standardised. However, every situation is different which makes it difficult. I would like to think that this thesis and my imparting the new-found knowledge to my colleagues will have an impact and possibly even be a starting point for the development of an international expert panel on hip and groin pain.

Analysing my objectives (page 22), I do believe that although one cannot be emphatic due to lack of evidence based studies, my objectives are being implemented and have mostly succeed in practice. Having intensely examined the hip and groin injuries in different sports and the consequential management difficulties encountered, my analysis and outcome of formal and informal knowledge can be applied to improve and develop novel injury prevention approaches. Above all, the resultant sharing of my knowledge and findings with all my medical colleagues, as well as coaches, has been and is being applied with anecdotal (and positive feedback) success. Further, the dearth of research in the field of prevention of injuries and particularly hip and groin injuries, has been shown to be outstanding (Fanchini et al., 2020). Hopefully, as per my request in my presentations, clinicians dealing with sports men and women will link with researchers in the future and thus make the outcome of prevention more conceivable. The only real proof that a prevention strategy is definitely viable for groin and hip injuries, is shown at Southampton Football Club where they have been undertaking a prevention strategy for the past 15 years with great success.

Finally, I would like to share the latest article from King and Franklyn-Miller, (April 2020) which confirms the basis of this thesis. They concluded that in athletes with athletic groin pain: "Independent of the anatomical diagnosis, a systematic approach to profiling the athlete to assess their strength, power and intersegmental control during compound movements, linear running, change of direction and sports specific tasks is key. Finally, constantly reassessing athlete's biomechanical outcomes ensures that rehabilitation is having the desired adaptation to ensure the most efficient return". This would be pertinent for rehabilitation, as well as a prevention strategy.

Practical Suggestions

For the past 10 years I have been emphasizing in all my groin and hip presentations that the key to hip and groin injuries is the understanding of the anatomy, functional anatomy and biomechanical implications. This, combined with many years of clinical experiences, has resulted in abnormal kinetic movements and malfunctions being identified and consequential corrective neuromuscular control and strengthening exercises being implemented to counter these functional abnormalities. Further, the particular sport and the position within the sport, requires precise biomechanical analysis to obtain full appropriate functional strength. This should guide the practitioner to a sound prevention or rehabilitation programme, regardless of any specific diagnosis.

There are many exercises pertaining to the groin and hip area for prevention and rehabilitation. A few of the more pertinent exercises that I have used clinically are tabulated, as below.

If these exercises are published in any way, the script below would be added to the footer of each page.

If you have any current injuries or are concerned in any way, please consult a medical professional before participating in this programme.

Table 29: Groin and Hip Exercises

GROIN AND HIP EXERCISES

- **This exercise programme targets Groin and Hips and will also have an effect on the entire kinetic chain.**
- **There are many more exercises, but these are a few specific ones to be recommended.**
- **These exercises should be done as part of a prevention / rehabilitation strategy and implemented pre-season and throughout the athlete's season.**

Note:

- **Be aware of correct posture with every exercise.**
- **Always tighten abdominal / core muscles before and during the movement.**
- **Do correct breathing whilst doing the exercises.**
- **These exercises are not graded in any way and not advised for the general sports population as it stands.**

  It is imperative that each exercise is individualised for each player in an exercise strategy.

  This should also relate to their specific sport and position therein.
  Thus the clinician will advise which exercise and the exact amount to be performed.

STATIC STRETCHING EXERCISES

N.B Static stretches to be undertaken on a regular basis, but not prior to training or playing.
Hold each stretch for 20 sec. Do 3 times

Hip Flexors / Ilio Psoas

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Avoid sticking your buttocks out. Back leg straight.
Tilt pelvis backward. Tighten abdominals.
Feel a stretch in the front of your right hip – deep inside

Deep Gluteal muscles

Lean forward from the pelvis, straight back.

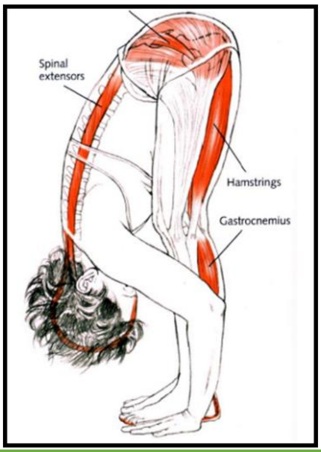
Don't force left knee into excessive flexion.

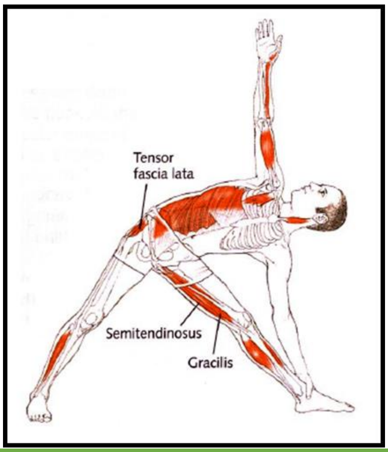
KINETIC STRETCHING

An improvised adaptation to Sun Salutations has had excellent results prior to Training and Performance.
2 examples within this yoga movement are shown below

Yoga – kinetic movement

Specific yoga type movements working around the pelvic area and the entire kinetic chain.





VERY USEFUL STRETCHES

PNF: Contract / Relax:

Hip Flexors: Ilio Psoas (IP) and Rectus Femoris

a. Fix Right bent leg. Resist Left hip Flex (IP muscle) - only 40% Maximum Voluntary Contraction (MVC). Keep 40% MVC for 10 seconds. Slowly release.

   Do 3 times. Each time clinician pushes the bent gently into further extension.

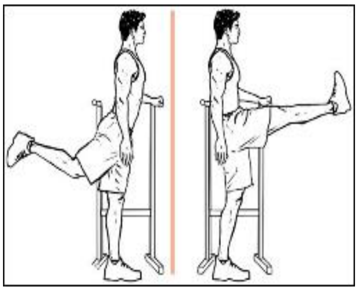
b. Same resistance for Rectus Femoris

c. Same resistance for Abductors

Hip Swings:

Very relaxed hip swings

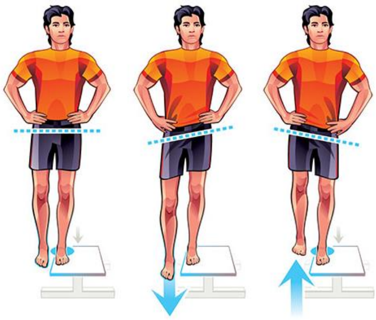
3x side to side
3x forwards and backwards



SPECIFIC STRENGTHENING EXERCISES

Gluteus Medius

Hip Hitch



Good posture, both legs straight, drop Right leg down and hitch it back up slowly, hold in the hitch-up position for 10 seconds. Do both sides. Keep legs straight all the time.

Gluteus Maximus, Hamstrings plus Proprioception

Hip Stabilisers used on Right leg.

Dive Exercise

The player stands on the right leg with the knee slightly bent or straight if no problem. The trunk moves forward as the straight back leg moves backwards. The arm(s) drop forward towards the ground. The player keeps the hips level throughout the movement. Weights may or may not be used.

Gluteus Maximus + Hamstrings and Adductors (plus Core muscles)

Exercises a, b and c should be performed with a rubber ball between the knees at all times in order to incorporate the Adductor muscles during these movements and thus work towards having an inclusive neuromotor pattern during all activities.

Tighten abdominal muscles and squeeze the ball before lifting.

Ensure that the Glut Maximus is 100% tight at the end of the lift.

Keep pelvis level.

a. Bridging with ball between knees

b. Bridging and straighten 1 leg

c. Bridging with 3 balls

SPECIFIC STRENGTHENING EXCERICES

ADDUCTORS

Specific Exercise

Adductor muscles

Adductor muscles with theraband
This can be done with the fixed theraband at a height that is comparable to the requirements of the specific sport. Perform slowly - concentric and eccentric.

Functional Exercise

Adductor muscles plus hip flexors and external rotators (and standing leg Hip Stabilisers)

Standing in the kicking position
Straight leg up and across body in flexed, adducted and slightly externally rotated position.
Standing leg straight. Good posture. Hold position for 10 secs or more, depending on the athlete's strength.

FUNCTIONAL EXERCISES

Hamstring Walk – Eccentric Hamstrings (plus Proprioception and co-ordination)

The athlete stands upright with good posture. Lifts the Left thigh to 90^{0} and then extends the knee **slowly** until a stretch is felt in the hamstring. NO leaning back. Plumb line position.
The athlete then slowly lowers the extended leg to the ground stepping forward. The athlete then repeats the exercise on the Right side. Opposite arm / opposite leg in action.

Progress: Go into lunge position from this Hamstring walk and hold in that position. Then up straight and repeat Hamstring walk to lunge. Keep moving forward.
Progress: To be done on a balance mat remaining in one position.

Core Stability

Sahrmann exercises

Tighten abdomen, pelvis against floor.

a) Toe Tap. Keep both legs at 90 degrees Hip and Knee flexion. Very slowly tap one foot on the ground whilst maintaining pelvic position. And back to 90 / 90 position. Repeat with the other side.

b) Position as above. One leg maintains position, the other leg very slowly straightens and bends **just above the ground**, returning to 90/90 degree position. Pelvis position maintained throughout.

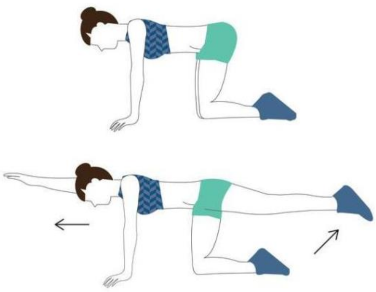
Core plus Adductors

c) Crook lying on mat. Ball between knees. Tighten abdominal muscles, squeeze the ball and lift head and shoulders. Hold position.

FUNCTIONAL EXERCISES

Gluteus Maximus / Hamstrings / Core control

4 point Kneeling



Start with hands under shoulders, knees under hips, pelvis and spine neutral.
Lift opposite arm and leg and lengthen simultaneously.
Maintain control. Hold position.
Pelvis must be level to floor. No rotation

Progression
4-point kneeling + band resistance: Hold in hand and extend leg to straight.) Your extended leg only goes as high as your hip — **no higher**.
Core muscles working. Slow controlled movement.
Similar can be underaken with theraband behind lower thigh (right) and (right) hand pulling the theraband forwards and the opposite leg stretched out.

Gluteus Maximus - Kettlebell thrust

Slow controlled movement.

When fully straight, make sure the gluts are 100% tight.

Hip Stabilisers

Sideways walk – Band above knees

Slow controlled movement

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Sideways walk – Band above ankles

Slow controlled movement

GENERAL FUNCTIONAL

Full Body – Front Plank

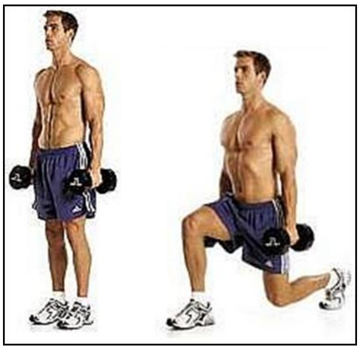
Core stability+++

Full Body – Side Plank

Core Stability+++

Squat

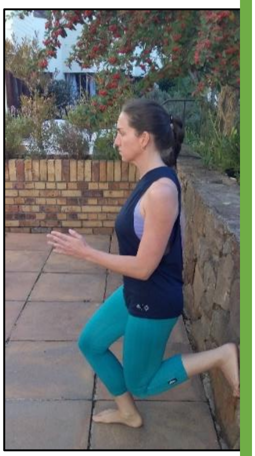
Lunge with or without weights



Forward Step up

Wall Running

Good posture. Check that all kinetic chain is in good alignment.
When doing exercise – plumb line straight down through centre of body.
Left knee bent to 90 degrees with left foot on wall.
Pelvis pointing forward throughout the movement.
Opposite arm/leg throughout the movement.
Slowly up and down to approx. 65 degrees of Right knee flexion (never lower than 90 degrees)
Go down plumb-line. Buttocks does not go backwards.



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