Knowledge and experience of sports supplements and ergogenic aids, with a specific focus on caffeine, in Basketball athletes.

Chen Liu

A dissertation submitted in partial fulfillment of the requirements for the degree of Master of Science

School of Sport and Exercise Science

University of Kent

January 2021

Declaration

"'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'.

Signed

Acknowledgement

First of all, I want to thank my supervisor Glen Davison for his guidance and advice during my thesis. Without Glen Davison, it would be difficult for me to complete this academic research. Secondly, I want to thank all the athletes who participated in my questionnaire survey. They spent time and energy to help me complete my thesis survey and support my research.

Also, I would like to thank the classmates and friends who helped me during the writing of my thesis, and also very grateful to you for your support.

Finally, thank my family for their unconditional support. The same experience of studying abroad in the UK will be remembered forever, and thank those who appeared in my study abroad career.

Table of Contents

单击此处输入文字。

Abstract

Background:

The aim of this study was to investigate the use, basic knowledge, experience of using caffeine and sports supplements of basketball players in China and the UK.

Methods

A total of 52 basketball players aged 18-27 years from China and the United Kingdom, who were members of University basketball teams, were studied through questionnaires. Among them are 5 female basketball players and 47 male basketball players. The questions gathered information on current and historic use of supplements and caffeine, knowledge on sources of caffeine, performance effects, and safety/risks.

Results

The use rate of sports supplements in general was 37%, and for caffeine it was 25%. The main reasons for athletes to choose sports supplements are to improve performance (35%) and recovery (32%). The main sources used by these athletes to research and find information were the internet (46%) and coaches (29%). The athlete's ability to identify caffeine-containing foods was generally good but they were not as good at categorizing or differentiating between higher and lower-caffeine content sources. Very few athletes who used caffeine reported side effects from its consumption.

Conclusion

Caffeine use as an ergogenic aid is relatively low in this group of young college basketball players. However, the reliance on the internet and coaches for information, combined with sub-optimal accuracy in knowledge about caffeine content in many common food or beverage sources highlight the need for further education about caffeine and sports supplements in college athletes.

Introduction

Caffeine is one of the most widely consumed behaviour influencing substance in the world, and use is common in athletes (Burke, 2008; Desbrow and Leveritt, 2006, 2007; Graham, 2011; Jovanov et al., 2019; Waller et al., 2019). Caffeine is a stimulant, that affects the CNS and many body tissues that may explain its effects on performance. Basketball is a high-intensity sport, including running, jumping and body collision, and can be highly demanding physically (Conte，2015). There have now been several studies on athletes' knowledge and experience of sports supplements and ergogenic aids, and some research with a specific focus on caffeine. However, this has tended to focus on endurance athletes (Desbrow et al., 2006, 2007). There are not many studies on the performance of caffeine in team sports, and there are not many studies on the relationship between caffeine and basketball players. There is limited information specifically focusing on basketball athletes, so further study is needed to explore the patterns specifically in this group. The aim of this thesis is to determine use, knowledge and experience of sports supplements in general and specifically caffeine in college basketball players. In most existing studies, the subjects are elite athletes, but college athletes and elite athletes may have different levels of understanding of caffeine and sports supplements. Caffeine is one of the most studied ergogenic aids in sport, with strong evidence for benefits on many aspects of performance. Although caffeine is one of the most studied ergogenic aids in sport, with strong evidence for benefits on many aspects of performance, the potential benefits can be affected by dose, timing and habitual use of caffeine. Since caffeine is also found naturally in many food products, it is important to understand the knowledge of coaches and athletes about caffeine, and this may inform future education strategies for coaches and athletes (e.g. to help with the design and implementation of appropriate use strategies in athletes, or the avoidance of misuse and risks). This thesis also explores the frequency and severity of side effects experienced by athletes if using caffeine. All in all, this research has relevance for the educational needs of non-elite basketball players and coaches. Also research on non-elite basketball players can provide reference.

Impact of COVID-19 and approach taken in this thesis

The original plan for this project was to undertake a field-based experimental study on the effects of caffeine supplementation in basketball athletes (see Annex 1 for brief overview of original study). Between October 2019 and February 2020 considerable work was done on reviewing the literature on this topic, designing, and planning the project, and submitting ethics application forms. Approval for this project was granted mid-March 2020 and data collection was about to commence when the first national lockdown in the UK was announced and this was not possible. The project was put 'on hold' initially, as it was believed at the time that the lockdown would be relatively short and data collection would be able to resume by the summer of 2020. However, when it became clear that this would not be possible, in June 2020 a decision was made to change to a different project (questionnaire-based study) that could be completed during the pandemic. This required considerable extra time to plan the new project, submit ethics applications and await approval. Approval was granted at the end of June 2020 and data collection began in July 2020.

The approach taken in this thesis includes a literature review on the effects of caffeine on performance, as applicable to team sports and in particular basketball. The review also includes aspects on the risks of supplements, and use, knowledge and understanding of caffeine in athletes, which was a key focus in the modified study/questionnaire study. The results provide new information on this area in sub-elite basketballers, extending previous literature on higher-level athletes and endurance athletes and filling a gap in the literature.

Review of Literature

Sports Supplements

Sports supplements are widely used nowadays, and they are aimed at different sports and fitness activities. There are many purchase channels, and it seems that caffeine is a popular choice for athletes, the same as the use of caffeine in today's society (Froiland,2004). Sports supplements can not only improve athletic performance, but also supplement the substances needed for good health, such as carbohydrates, proteins, amino acids, vitamins and minerals (Colls,2015), which may help to supplement inadequate dietary intake. And with the development of the times, not only elite athletes have a demand for sports supplements, but more leisure sports enthusiasts seeking performance or aesthetic goals are more commonly using sports supplements (Vitale, 2019). According to Foiland (2004) research on nutritional supplements for college athletes in universities, it is concluded that female athletes report health or nutritional deficiency (e.g. lack of vitamins) as main reasons for taking nutritional supplements, while male athletes cite physical agility, strength and speed, and muscle gain as the primary reasons for their use. However, many athletes do not consider the consumption of sports supplements.

The risk of sports supplement

In Hoyte's (2013) study, 64% of college students participating in sports have a history of taking sports supplements to improve their performance. It is not to convince that the use of sports supplements is completely unsafe, many sports supplements themselves do not have any side effects, because they are often mixtures of many natural ingredients or generally safe substances (Roins, 2018). But after adding some other ingredients, sports supplements have certain safety risks. There is an increasing demand from sports like bodybuilding, where anabolic agents and pro-hormones are not banned so supplements containing such substances are not a worry for such athletes. There are risks of athletes in other sports consuming such supplements, however, without full knowledge of the ingredients or the risks. There is also the possibility of cross-contamination from poor manufacturing processes (e.g. when general sports supplements are produced at the same facility) (Maughan, 2018). Due to contamination of nutritional supplements, athletes may ingest banned substances without knowing (Geyer,2008）. In addition to the risks for doping violations in athletes, there are also health risks. The adverse physical effects of anabolic steroids include cardiomyopathy, changes in blood lipids, acne, and liver toxicity (Bond, 2016). There is also an increasing prevalence of “pre-workout” supplements, intended to allow individual to train more intensively, which are generally marketed at ‘gym-goers’. Most of these contain stimulants, such as caffeine but also many contain additional stimulants, some of which may be dangerous and have health risks. One example is 1,3-dimethylamylamine (DMAA), which has sympathomimetic and vasoconstrictor properties. In Eliason (2012) and Karnatovskaia （2012） report, three US soldiers died during exercise after supplementing with DMAA. Then DMAA is also regarded as a performance-enhancing drug prohibited by the World Anti-Doping Agency (WADA)　(Docherty, 2008). Obviously, not all sports supplements are completely safe. Nowadays, the market for sports supplements and nutritional supplements used to improve the health or body of athletes is huge（Roins, 2018）. However, these supplements are not necessarily safe for everyone. Like conventional drugs, supplements with active ingredients that provide physiological or pharmacological effects may also adversely affect people who have certain health conditions. Also, inappropriate intake (i.e. consuming too much) can cause side-effects even in apparently healthy individuals and athletes. To avoid serious medical consequences, more attention needs to be paid to adverse physical reactions and potential interactions (Roins, 2018). Then there are still big doubts about the health of sports supplements and nutritional supplements. Users should use them reasonably. It is best for college athletes to take them under the guidance of relevant professionals. They should not over-eat or rely on sports supplements. In view of this, schools should pay more attention to good health education for college students, especially in areas that college students are not familiar with.

Caffeine

Xanthine (3,7-dihydro-purine-2,6-dione) is a purine base that naturally occurs in human tissues and body fluids, plants and other organisms. Methylxanthine (methylxanthine) is a phosphodiesterase inhibitor and adenosine receptor antagonist. Therefore, methylxanthines have different effects: reduce inflammation and immunity, reduce drowsiness and increase alertness, and can also stimulate heart rate and contraction and expand bronchial tubes. The most famous methylxanthines are caffeine, methyl bromide and theophylline (Cited in Coune, 2015). Coffee, tea and other caffeine-containing beverages are commonly used by many people （Reyes, 2018). There are many caffeine beverages on the market (Graham,2001). Reyes (2018) found that caffeinated beverages may have an adverse effect on certain specific groups of people, and pointed out that habitual intake of caffeine can have health effects on these specific groups of people, which has aroused social and scientific debate. For healthy adults, up to 400 mg of caffeine per day, and healthy pregnant women up to 300 mg per day, is generally considered safe (Nawrot, 2003). Furthermore, single intakes up to 2.5 mg/kg rarely cause adverse reactions or side-effect for most people, although some sensitive or susceptible individuals may experience side effects with lower doses. Wikoff (2017) reports the most common caffeine side-effects or risks as (1) acute toxicity, (2) cardiovascular, (3) bone and calcium, (4) behavior, and (5) developmental and reproductive toxicity effects, although most of these would only be evident with excessive doses beyond the levels mentioned above (1), or chronic high intakes (i.e. > 400 mg/day) (2, 3, 5). Evidence shows that the usual 400 mg caffeine intake of adults is generally safe. At the same time products containing caffeine cany vary in different countries. For example, coffee and some soft drinks are the most common sources in Europe and North America, while tea and soft drinks are the most popular in Africa and Asia. Among athletes, caffeine has been used frequently (Pickering, 2018). 15 minutes after consumption of caffeine, the caffeine concentration in blood will begin to increase and it typically peaks within 45- 60 minutes, with a 3-4 hour half-decay period （Graham, 2003). Many studies today are about the effects of high-dose caffeine intake on athletes, with doses of at least 3 mg/kg (i.e. over 200 mg for an average-sized male) (Spriet,1995)), although many studies have used much higher doses (e.g. 6 mg/kg or more) (Burke et al., 2008; Graham, 2003; Graham & Spriet, 1995). By comparison, there are relatively fewer studies investigating lower doses and/or dose-response studies. It seems that low-dose caffeine has little effect on exercise performance, but Cox et al (2002) showed that 1.3 and 1.9 mg/kg of caffeine, after conducting a controlled trial in cyclists and triathletes, showed caffeine improved 7 kJ/kg time trial performance (typical duration ~30 min) by 2.2%, although not significantly increasing caffeine concentration in plasma and urine, did provide some performance enhancement. The lowest dose of caffeine previously reported to improve performance is 2.1 mg/kg. And there are studies (Graham, 1995) using caffeine dosage of 1-3mg/kg to improve sports performance, and the caffeine dosage is much larger than earlier studies. The increase does not increase after high doses of caffeine is consumed (Graham, 1995) (Pasman, 1995). However, caffeine has a certain response difference depending on individual factors, such as genetic influences. For example, recent research has suggested differences in the physical and cognitive performance responses to caffeine depending on polymorphisms related to caffeine metabolism and/or sensitivity (e.g. Womack, 2012; Guest et al., 2018; Loy et al., 2015; Carswell et al., 2020; Pickering & Kiely, 2018). The CYP1A2 gene encodes cytochrome P450 1A2, which accounts for 95% of all caffeine metabolism, and some research has shown polymorphism in this gene influence physical performance (Guest et al., 2018), although not all research shows this (e.g. Carswell et al., 2020). Other research has shown effects of polymorphisms in the gene for adenosine receptors to influence physical (Loy et al., 2015) or cognitive (Carswell et al., 2020) performance during exercise. In addition, ADORA2A or CYP1A2 genes have no difference in endurance athletes' performance and caffeine metabolism (Carswell,2020), and further studies are needed to confirm the influence of specific genes on the ergogenic effects of caffeine (Carswell, 2020). On the other hand， single nucleotide polymorphisms (SNPs) in ADORA2A and CYP1A2 seem to affect habitual caffeine intake (Cornelis, 2007). For example, those with a 'high-sensitivity' genotype tend to have lower habitual caffeine intake (perhaps influenced by increased incidence of adverse reactions in these individuals). This is even more complicated when considering the impact of caffeine on athletes (Pickering, 2019). Although not a focus of this thesis, this highlights the individual-specific responses and variability that can exist between people in their response to caffeine (Pickering & Kiely, 2018).

Caffeine and performance

Kavouras（2004）had already mentioned that Rivers and Webber（1907） had confirmed, over 100 years ago, that caffeine could promote athletes' performance. With the development of technology, caffeine is now appearing in many new products, which are closer to our lives, such as energy drinks, sports capsules, alcoholic beverages and even diet foods（Graham， 2001). Caffeine is commonly used by athletes because of its ergogenic effects. The main causative effect of caffeine on athletic performance is mainly due to 1 central nervous system stimulation (blocking of adenosine receptors and the release of neurotransmitters such as dopamine, catecholamines, and acetylcholine), and 2 mechanisms related to direct enhancements in muscle contraction processes (San, 2019). To a lesser extent, caffeine is also a mild analgesic and may exert some effects via these pathways. For example, caffeine will introduce secretion of β-endorphins (Laurent,2000,Sökmen,2008), β-endorphins have an analgesic effect, when the concentration of endorphins in the blood increases, can reduce the person's perception of pain, thereby increasing the ability to exercise under the same level of muscle pain (Gonglach,2016), extended working hours (Chia, 2017; Williams, 2008; Farrow, 2008). It is now believed that from a physiological point of view, most of the ergogenic properties of caffeine stem from its effects on the CNS through adenosine receptor antagonism (Chia,2017) . Adenosine and caffeine have opposite effects on the regulation of cell activity. Adenosine is a neurotransmitter, and when it binds to receptors within the CNS it causes feeling of tiredness and lethargy (reducing physical performance). Caffeine is an adenosine receptor antagonist, as it competitively binds to these receptors without activating them. Thus, caffeine intake blunts the effects of adenosine on neurotransmission, perceived exertion and vigilance, and can therefore improve performance. However, in team sport athletes physiological stress interacts with cognitive performance (Chia,2017; Astorino,2018) . Spriet (2014) found caffeine not only impact physical performance, but can also influence some psychology factors and performance components. For example, improve attention, emotion and readiness of central nervous system (CNS)(Sökmen,2008). Caffeine can significantly improve auditory alertness and visual response time. In some tests, increased caffeine dose can significantly improve performance. Even with the highest dose (6 mg/kg body), no adverse effects were found, such as increased anxiety or impaired athletic performance (Lieberman,1987). Bruce (2000) concluded in a short-term athletic performance experiment for competitive rowers, in controlled laboratories, intake 6 or 9 mg/kg of caffeine can significantly improve short-term endurance performance. Bell (2002) mentioned that Levine (1984) and Raguso (1996) found in experiments many years ago that 3 to 6 mg / kg of caffeine had similar same exercise-enhancing effects. Likewise, in endurance capacity tests, Graham and Spriet (1995) observed similar benefits with 3 mg/kg compared to higher doses (6 mg/kg and 9 mg/kg), and Pasman et al. (1995) saw similar benefit with 5 mg/kg compared to higher doses of 9 mg/kg or 13 mg/kg. Indeed, in some individuals, the higher doses may be less effective due to the higher occurrence of side-effects that are performance detrimental (for example, the acute side-effects they were reported in the Pasman et al (1995) study, that were reported more frequently in the higher doses (i.e. 9 and 13 mg/kg) were dizziness, headache, tremor, insomnia and diuresis). However, the optimal dose is difficult to universally determine, because the individual's sensitivity to caffeine and physical factors and the degree of absorption vary. There are many studies of caffeine's ergogenic potential, and the results of these experiments are evidence that caffeine has an effect on exercise performance in all its aspects, which is one of the reasons why caffeine is so popular in sports. Although caffeine can significantly improve exercise capacity, it cannot be dependent on it. For athletes, it is important to also be aware of potential negative effects as discussed later.

Caffeine, running and intermittent sports

Running in basketball is one of the basic movements. More studies showed that caffeine reduces serotonin during exercise (Lim,2001), increasing dopamine levels (Gerald,1978), improving endurance exercise and slowing fatigue （Heyes,1988). The final result was intake of 3 mg/kg caffeine could improve the secretion of dopamine and improves motor ability. The vast majority of experiments were conducted under closed laboratory conditions. In contrast, Bridge（2008）performed a study in which an 8 km running performance trial was used, and enhanced performance was demonstrated. Many studies have shown that ingesting caffeine can lead to a rapid performance improvement, especially endurance exercise (Graham,2001; Douglas,2002). Basketball is an intermittent sport that involves various high-intensity activities. Sprint running in basketball is typically maximal (or high) intensity, short bursts that are repeated with varied recovery intervals, some of which are very short. According to San (2019), caffeine can significantly improve the performance of anaerobic exercise. As noted in the previous section, caffeine is an adenosine receptor antagonist and this is likely the main mechanism explaining these effects (see further discussion in the "caffeine and performance" section above). It was also found that caffeine can reduce lower limb fatigue. Although the subject of this experiment is an Olympic-level boxer, the conclusion of reducing the fatigue of the lower limbs is also applicable to running sports. The running sprint test has become a test method used to evaluate athletes' performance in various sprints (Nieman, 2010), although more and more studies have shown that caffeine has a certain degree in this type of exercise. In addition, caffeine has greatly improved in the early stage of running, all in all, caffeine has great potential for individual and multiple sprinting activities in improving sprinting ability (Nieman, 2010). Although caffeine has a significant effect on sprinting in the early stage of exercise, the effect of duration, some studies have shown there may be some ‘pay off’ as a consequence whereby there is a subsequent negative effect on fatigue in later sprints (Stadheim, 2014). Also in the experiment of Del Coso (2012), it was found that after football players consumed energy drinks containing caffeine, sprint performance and high-intensity exercise were enhanced. So this also means that caffeine has changed the way of team sports, and it may also represent a vital advantage in sports competitions.

Caffeine and jumping

In basketball, it is necessary for basketball players to often perform vertical jumping exercises under fatigue, and the performance of vertical jumping is related to high-level anaerobic exercise. For example, rebounding in basketball is the most basic vertical jumping technical action. Caffeine intake can reduce the decline of muscle fatigue performance (Tucker,2013). Abian (2014) and Del (2012) have confirmed that caffeine intake can significantly improve jumping ability in basketball and football. Similarly, in the experiment for badminton players, it was concluded that the intake of caffeinated energy drinks before exercise increased the height of squat jumps, and the research found that caffeinated drinks increased leg strength, and the jump height of the squat jump. This information indicates that caffeine could increase jump performance in the game (Abian, 2014). It has been suggested that caffeine can improve muscle performance by increasing the release of Ca++ in the sarcoplasmic reticulum, decreasing reuptake, and by enhancing muscle fibre sensitivity to calcium ions, but this effect is mainly found in vitro with supraphysiological doses of caffeine (Magkos and Kavouras, 2005). Other studies have found that, due to higher voluntary muscle recruitment (Del Coso et al., 2008), ingestion of caffeine in the form of capsules or energy drinks can improve maximum muscle strength (Del Coso et al., 2008) and reduce time to achieve peak force during maximum muscle contraction (Del Coso, Muñoz-Fernández et al., 2012). These improvements suggest that there is better coordination between muscles within and between muscles during muscle contraction, which may be related to improved neural drive (central effect) after caffeine consumption. The efficiency of shortening the muscle stretch cycle has previously been used to assess changes in muscle properties (Castagna and Castellini, 2013). It has been suggested that caffeine does not change the efficiency of the stretch shortening cycle, which indicates that caffeine does not change the contractile properties of leg muscles. Therefore, Abian (2014) suggests that caffeinate can improve jumping performance by improving motor unit recruitment. In the study, it was found that the intake of caffeine increased the maximum vertical jump height of subjects by 2 cm, which could be of significant practical impact in competition. But after strength training, the effect of caffeine on jump height is less obvious. Although the jump height increased significantly in the first 5 minutes, the height decreased significantly within 15 minutes of the recovery period. It shows that caffeine intake can improve physical fitness but the trade-off may be that this leads to greater decrements and fatigue later (Stadheim, 2014). The experiment in the laboratory cannot simulate the real game situation. Although it is concluded that caffeine can increase the jumping height in the first 5 minutes, the duration of basketball is much longer than 5 minutes. This may also be a limitation, and further research is needed to explore this (Tangen, 2020). Jumping is an integral part of the movement and a key variable for basketball success. So the increased ability to jump after caffeine intake may be a step up overall in basketball, but this is only theoretical and has not been studied (Puente, 2017).

There is very little research on caffeine's jumping ability of basketball players, which is also one of the limitations of this article. On the other hand, the influence of caffeine on jumping ability and lower limb strength cannot be ignored. But Tangen (2020) verified that caffeine can increase the athlete's vertical jump height at rest, but after strength training or after a certain intensity of training (i.e. when fatigued), the positive effect on the jump height is not as obvious as in the initial stage. There are many types of bounce, horizontal jump, vertical jump, vertical squat jump, sprint jump and so on. In the case of not consuming caffeine, the difference in vertical repeated jumping is the largest (Maulder,2005), in basketball, whether consuming caffeine will affect the continuous jumping needs further research. This article is mainly aimed at professionally trained basketball players and does not discuss whether the caffeine consumption of ordinary people will increase the bounce.

Caffeine and reactive agility performance

In basketball, the sprint is not only forward, backward, but also lateral movement. The ability to implement such technical actions and changes of direction fall broadly within the remit of agility, which is a traditional and important part of basketball performance (Delextrat, 2008). However, reactive agility also incorporates the need to respond to a stimulus/stimuli, which also requires components of cognitive function and decision making, and this may be more applicable to team sport athletes competitive performance. Ben (2007) concluded that cognitive measures had the greatest impact on basketball player's responsiveness, and suggested that screening and decision-making training should be included in the basketball training plan. Cappelletti (2015) claims that consuming 150 mg of caffeine can increase cognitive ability for at least 10 hours. However, Abian (2014) found no significant improvement in the "agility T test" in badminton players, after the intake of 3 mg/kg of caffeine. However, as mentioned above this sort of test (T "agility" test) lacks the cognitive requirements that are more important to actual performance. Duvnjak (2011) used an agility test, it can be said to be comprehensive. The experiment contains five experimental components, including total time (TT), reaction agility (RA) time, decision time (DT), moving time (MT) and the measurement of decision making gains accuracy. The experiment concluded that in both "fresh" (not fatigued) and fatigue states, caffeine intake can increase most TT values and improve RA. Caffeine can enhance DT and MT, but its impact on decision-making is unclear.

That is to say, when the athlete is in a normal state and is tired, caffeine intake can improve RA performance. It is more concluded that caffeine can reduce unnecessary visual effects, so that the central nervous system can focus on the task and produce a faster reaction time (Lotist, 2003). In contrast, (Lorino (2006)) concluded in the experiment that agility is an essential part of exercise, and caffeine 6 mg/kg body weight does not affect agility. Through the Wingate test, after caffeine intake, the percentage of peak power did not change significantly. In contrast, the 6mg/kg caffeine in the Stuart（2005） report improved the agile sprint performance by 2.2%. However, these studies have certain limitations, usually a set experimental route, and there is a certain gap between the actual game situation (Duvnjak, 2011). Therefore, further research is needed to evaluate the impact of caffeine on agility in order to improve athletes' performance in actual competitions.

Caffeine and basketball

Basketball involves a variety of body movements, from low-intensity running and walking in a very short period of time to the largest sprint and jumping movements (Conte,2015). Professional men's basketball players have been reported to perform 10 actions/changes of body movements every 20 seconds during a game (Ben, 2007; Matthew, 2009), with a ratio of exercise to rest of 1:36 (Ben, 2010). Also basketball requires numerous complex sport-specific skills, for example jumping (rebounds, blocks), shooting, dribbling and sprinting (Klusemann et al. 2012) and these actions mostly depends on anaerobic pathways (Hoffman et al. 1996). Elite young basketball players spend 15–16% of the total time of a match engaged in high-intensity actions (Abdelkrim et al. 2007) while the remaining time is spent in low-intensity activities, such as sitting and jogging, during which recovery takes place. During the competition, most elite athletes cite different nutrition enhancement strategies to improve and get their best athletic performance, and caffeine is a popular choice for its effectiveness and function （Puente , 2017） . Caffeine and caffeine-containing products are not only popular because they are effective, but also because low doses of caffeine have an effect on human function in certain sports and exercise conditions. The effect of caffeine on the performance of leg muscles is related to the dosage. Del Coso (2008) found that 1 mg caffeine/kg body mass does not affect muscle performance during exercise, but 3 mg caffeine/kg body mass can increase the maximum strength of half squats and bench presses. So it seems that in order to get more conclusions on the effect of low-dose caffeine on exercise, more research is needed in the future, and the sports world has always had a high tolerance for caffeine use, but the low price of caffeine in the market is also a major reason for its popularity（Spriet,2014）. Although Puente (2017) confirmed that because jumping performance is a key variable in basketball activities, the enhancement of jumping ability after the ingestion of caffeine may enhance the overall performance of basketball. As a result, the pre-exercise ingestion of caffeine at 3 mg/kg in the form of an energy drink significantly improved jump performance but it did not have any influence on the precision of the basketball shots (Javier, 2014). The endurance aspect of basketball, coupled with its high-intensity explosive action, shows that this sport could benefit from these ergogenic effects of caffeine.

Basketball players often need to jump vertically when they are tired. Caffeine intake reduces the decline in jumping performance with fatigue（Tucker,2013）. During athlete fatigue, the concentration of calcium ions in the muscles decreases, resulting in a decrease in muscle strength. The intervention of caffeine restores calcium ion concentration and improves the decrease in muscle strength caused by fatigue (Sökmen, 2008). However, the effect of caffeine on vertical jump after fatigue needs further verification and research. Rebound is very important for basketball. After a high-intensity fierce confrontation, athletes need to jump to compete for rebounds. Tangen (2020) has shown that caffeine can increase the jumping height of athletes, so caffeine intake could affect rebounds. At the same time, caffeine has no effect on the accuracy of basketball shots, free throws, two-pointers and three-pointers. Although it is known that the effect of caffeine on the body's functions has been studied a lot, and the caffeine intake has increased, there is little information on the improvement of physical benefits obtained from the laboratory that translates into overall athletic performance (Puente, 2017). In addition, the subjects of the caffeine experiment are mostly elite basketball players. Their physical fitness is very different from that of most ordinary athletes. So whether athletes of different levels respond in the same way is less clear.

The risk of caffeine

Navarro（2019）discusses how athletes were banned from using caffeine at the Olympic Games before 2004, but since the stimulant was removed from the banned substances list, athletes are free to consume any dose of caffeine during competition. Through the urine test of athletes, it did not show that the utilization rate of caffeine by athletes was increased, and the urine caffeine concentration of most samples was in the low-medium range. Since 2008, there have been numerous studies involving the effects of caffeine on exercise, and there are also supplements that add caffeine or caffeine beverages to the formula, even if people have studied the effects of caffeine on athletes more deeply. However, the use of caffeine in sports competitions still changes significantly. Although the changes in the concentration distribution of caffeine in urine in 2015 clearly showed a slight increase in the number of users, indicating that the proportion of athletes who did not consume caffeine before or during sports competitions has decreased. It has been confirmed that the intake of caffeine before the game will affect team sports (Chia, 2017) (Puente, 2017) (Abian, 2015). In the study of Cappelletti (2018), caffeine has been proven to have benefits after ingestion, but according to the current research, after ingesting caffeine, there are differences in the ability of individuals to improve performance. This may be related to genetic factors and differences between individuals. This also leads to the fact that caffeine can have some side effects in some people. In addition to the moderate side-effects that can present with normal (generally safe) intake levels, there are also risks when intake is excessive. For example, caffeine will have serious toxic reactions when the plasma concentration is 15 mg/L or higher, which can cause seizures and arrhythmias or even fatality. Intakes of gram quantities can be dangerous with multiple grams bringing very high risk of death, to cause the toxicity of caffeine requires excessive intake, so fatal events of caffeine are not very common. But the side effects after overdose can also be serious（Murray,2020）. Although the fatality rate of caffeine is not high, and body poisoning is relatively rare, there are still potential safety risks. Athletes need to understand and prevent related health conditions. Common features of caffeine poisoning among the general population include anxiety, restlessness, insomnia, gastrointestinal discomfort, tremor, psychomotor agitation, and in some cases death. Cardiovascular effects include tachyarrhythmia and the cause of death is usually ventricular fibrillation. In athletes, especially bodybuilders and weightlifters, doping use seems to have become a recognized problem in the sports world. As early as 2004, stimulants were listed as prohibited substances by WADA. The onset of disease, such as "anorexia reverse" or "Adonis syndrome", is based on the athletes' excessive intake of coffee, to sacrifice physical health while enhancing muscle development (Cappelletti, 2015). When athletes take it, it obviously violates sportsmanship. Whether athletes also understand the impact of caffeine on athletes will have a certain impact on caffeine use needs further research, but Olympic-level athletes will also consume more than standard caffeine drugs in order to pursue better performance. Then college students' exercises need to understand the side effects of caffeine, so as to use it correctly and appropriately.

Caffeine knowledge

There have now been several studies on athletes' knowledge and experience of sports supplements and ergogenic aids, and some research with a specific focus on caffeine. However, this has tended to focus on endurance athletes (Desbrow et al., 2006, 2007). There is limited information specifically focusing on basketball athletes, so further study is needed to explore the patterns specifically in this group. Since not all athletes will take sports supplements under the supervision and guidance of professional nutritionists, especially in developing countries, not every country will teach sports supplements safety education, increasing the risk of improper use and/or associated health risks in some athletes (Froliand, 2004). Nevertheless, the reason for using sports supplements is to supplement the body's consumption so as to meet the needs of training and physical needs, thereby improving athletic performance. However, athletes sometimes do not seem to understand why they take sports supplements (Petróczi, 2007). And there have been reports that athletes have the possibility of ingesting dietary supplements that have been contaminated (Geyer, 2008). However, it is not entirely believed that sports supplements are unsafe. And because caffeine is one of the most popular consumer products, it has many other health benefits besides improving body function (Pickering, 2019). On the contrary, not all citizens of countries have a certain basic knowledge of caffeine. For example, the Jain (2017) report has increased the sales of caffeine in India. The most shocking thing is that the knowledge of the health hazards of caffeine among medical professionals in India is not ideal. In the Desbrow's (2006) report, half of the athletes (52%) did not know how much caffeine they should consume. Endurance athletes are very common in the consumption of caffeine and have knowledge of the effects of caffeine, but many subjects have doubts about the legality of caffeine. The aim of this study therefore was, is to examine the prevalence of use of supplements (with a specific focus on caffeine) and also athletes' knowledge and experiences of caffeine use, in a group of competitive basketball athletes.

Methods

This research has been approved by the SSES Research Ethics and Advisory Group of the University of Kent (REF No. Prop_59_2019_20). All participants signed a written informed consent form. The questionnaire used in this article is based on Desbrow and Leveritt (2007), participants were recruited by invitation e-mail that was sent to the respective teams at Kent and in the Chinese University. Other questions were added to capture information about athletes' knowledge and awareness of the safety of sports supplements and their effects on sports and side effects. Therefore, the focus of the questionnaire survey is whether the subjects take exercise supplements, the main reasons for taking supplements, basic knowledge of caffeine and consumption history. There are also dietary attitudes, feelings after eating, and the side effects of caffeine. The questionnaire was originally published in English (Desbrow and Leveritt, 2007) so for the Chinese participants, this was translated by this researcher (CL) into Chinese. For unfamiliar words, such as ProPlus, Chinese subjects were notified of what they were and given equivalent examples in Chinese. After the questionnaire was sent out, participants were instructed to contact the researcher by e-mail with any queries or for any questions they had relating to understanding of the questionnaire.

Questionnaire details

Weekly level of physical activity. In this part of the questionnaire athletes are asked to provide details of their typical weekly training activities. There is no fixed option, and there are three training intensities to choose from (see Annex 2).

History of (and reasons for/for not) taking Sports Supplements. In this part of the questionnaire athletes are required to provide information on their use of sports supplements, and the reasons for consuming sports supplements (or not).

Purchase channels, dosage and safety of sports supplements. In this part of the questionnaire athletes are required to provide further details on where they purchase supplements (if used), and answer questions about quantities (dosage) and safety of supplements. There are a total of three questions for the athletes to answer, and at the end of each option there is an "other" option, for the participants to provide details of items outside the options.

Use history and Knowledge of Caffeine Sources. These questions assess the caffeine use history, perceptions about effects on performance, and knowledge about sources of caffeine. There are 19 common products listed and athletes are asked to indicate how much caffeine they think each contains using the following options: "content less than 50 mg", "content more than 50 mg", and "no caffeine." Athletes can also use "unfamiliar with item" to indicate that they are not familiar with it, and so cannot rate it in this way.

Sources of caffeine information and side effects. In this part of the questionnaire athletes answered questions about where they obtained information (they had 18 options such as coaches, Internet, etc.). In addition, the athletes also answered questions about the recommended/required intake of caffeine. There was also a question on their experience of side effects, rating a number of different symptoms in severity from "very insignificant" to "very serious", and the typical likelihood/frequency that these occur for them if using caffeine from "never" to "100%". After completion, the athlete was also required to complete a caffeine intake questionnaire in order to estimate their normal intake levels.

Statistical Analysis

All data in this thesis have been assigned and entered into SPSS (SPSS, Inc. version 22) for data analysis. The data are expressed as Mean ± Standard Deviation (SD) unless otherwise stated. All percentages are expressed relative to the total number of people who completed the question. The correlation between the reported caffeine intake of basketball players and their perceptions of caffeine's influence on sports performance were examined. The correlation between the training history of the basketball players and their caffeine intake was also examined. Reported caffeine intake was also compared between basketball players based in two different countries (UK and China). The relationship between the level of basketball players and their perceived influence of caffeine on performance and other responses was also examined. All sample distribution differences and correlations were verified by cross-tabulation, chi-squared test, and Pearson correlation coefficient. The statistical significance level was set to $P<0.05$. The rest of the qualitative (descriptive survey results) variable data is expressed as a percentage.

Results

Study Participants

The participants of this questionnaire were 52 (46 males, 22.3 ± 2.5 years old, 80.1 ± 9.9 kg body mass, 6 females, 21.6 ± 1.6 years old, 62.9 ± 4.4 kg body mass) basketball players from teams in the UK and China. The athletes based in China were all Chinese. The athletes based in the UK were all European (mostly British, 1 Spanish, and 1 Cypriot).

Background of the Athletes

The type of athletes have two different parts, the British survey subjects are 22 athletes, 2 athlete's highest performance level was the national team, for 11 athletes it was the University team, 5 athletes regional team, and 4 athletes local team. The Chinese survey subjects are 30 athletes, of which 18 are Chinese national second-level basketball players, and the remaining 12 are members of the university basketball team. According to the questionnaire, a large proportion (73%) of these basketball athletes had been training for more than 5 years, 25% 3-5 years and only 1% 1-3 years.

Weekly Levels of Physical Activity

It can be seen from the questionnaire that in 96% of the athletes' training plan, 34% (n=52) training took place across the whole week: this is not only specific basketball training, but also corresponding physical training, swimming, conditioning exercises and aerobic exercises.

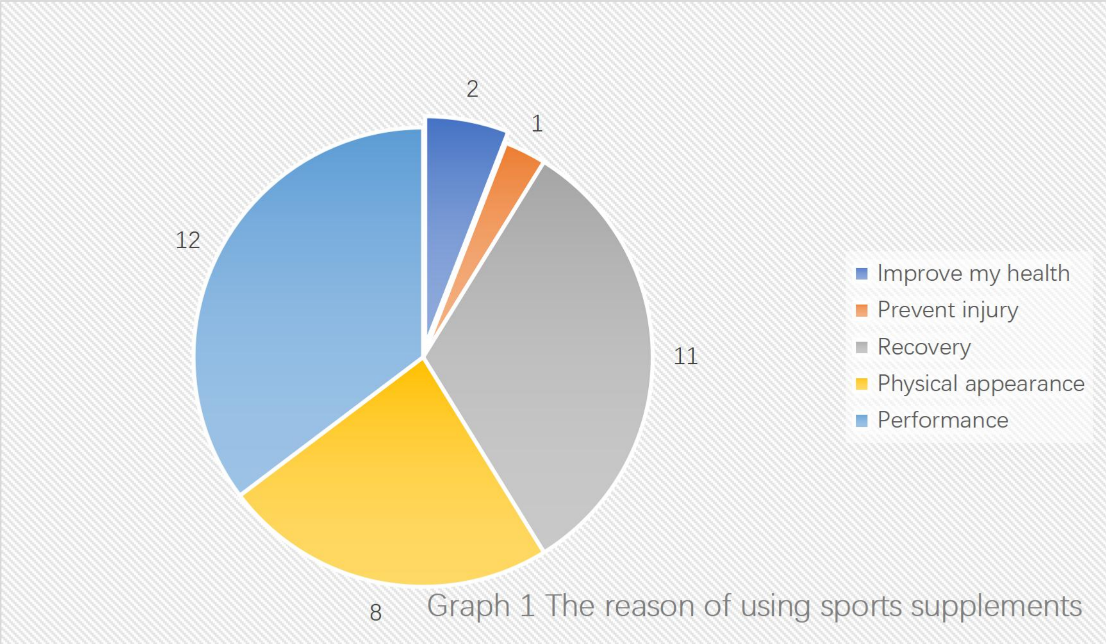
Training Summary data. On average, athletes receive training for basketball at least 3 times per week and (range 3-5 times per week) training. On average, athletes train a total of 5 times a week, including all types of training activities (range 4-6 times per week).

History of (and reasons for/for not) Taking Sports Supplements

According to questionnaire, only 36% of the athletes have taken supplements before. For the UK-based athletes it was 22% and for the China-based athletes it was 46%. The reasons provided for not using sports supplement, were: 51% (n=31) "do not know enough about the sports supplement", 28% "do not need sports supplements". For the athletes from UK, only 14% and 2% think the sports supplement is expensive and unhealthy. For the athletes from China， 72% reported they don't know enough about supplements, only 22% and 5% think the price is high and they are unhealthy.

The purchase and source channels and safety of sports supplements

In total 36% (n=33) of athletes (see Graph 1) reasons for buying sports supplements were for performance, 33% for recovery, 24% for physical appearance, 6% to improve health and 3% to prevent injury.



Graph 1 The reason of using sports supplements

For purchase methods, the vast majority of athletes (85%, n=33) choose online store. Only 8% and 5% choose nutritionist or dietician and retail store or pharmacy. In the open question where athletes could provide details/names of the sports supplements they use, 20 athletes provided further details. This included supplements such as Mass gainer, Muscletech, Vegan protein powder from vega etc (see full details in Annex 2). Moreover, in terms of sports supplements, in these 34 participants, 85% are from China, 15% form UK. 32% (n=34) of athletes follow the instruction on the label/manufacturer website.

Table 1: sources of information.

(n=52)

Own research	11
Ask coach/teammate	8
Based on label	3
Ask sports nutritionist/dietitian	6
Do not use supplements	25

Among them 36% from UK, 63% from China. 23% of athletes based their intake/doses on body weight. Among those from China, 47% of athletes do not use sports supplements. Move to the safety of sports supplements, based on the results shown in Figure 1 a proportion of athletes do not use supplements (47%, n=53). 20% and 11% reported doing own research and ask sports nutritionist/dietitian/medical professional. The last two parts data are, ask coach/teammates (15%) and based on label (5%). Followed by the risk of sports supplements question, 71% of participants think some sports supplement have health risk and 28% of athletes think all supplements carry a health risk.

Using history and Knowledge of Caffeine Sources.

A total of 53 athletes provided their caffeine using history. A large number of athletes (75%, n=53) reported that they had never used caffeine in the past. Only (24%, n=53) had a history of caffeine consumption in the past. Among athletes who do not currently use caffeine, 10%, (n=39) have used it previously and 90% have never used it.

Table 2 shows the results of the questions relating to athletes' knowledge of the caffeine content in common products. Among the common options, such as water (87% correct), instant coffee (90% correct), and Coke (80% correct), the judgement accuracy is high. But in some common beverages, such as protein shakes and Sprite, the accuracy rates are only 35% and 10%, the most prominent of which is that in the two choices of water and juice, the accuracy rates are 87% and 58%, and 23% of athletes said that juice contains caffeine, and 13% of athletes said they are not familiar with water at all. This is very surprising, and could be related to misunderstanding of the questions (i.e. possibility of confusing “unfamiliar with item” for “do not know/unsure”), or not properly reading or completing the questions. For the caffeine drug ProPlus, there is only a 53% correct rate. And for sports drinks (12%) and black tea (38%). In short, the correct rate of athletes in this question is 62% ± 23%, and the correct amount of caffeine in the substance is 58% ± 18%.

Table 2 Knowledge of Caffeine

	Contains large amount of caffeine (i.e. more than 50 mg)	Contains small amount of caffeine (i.e. less than 50 mg)	Contains no caffeine	Unfamiliar with item	% correct identification of containing caffeine vs no caffeine	% correct identification of caffeine amount in caffeine - containing products
Coke(n=51), 1 can	13	28	0	10	80% correct	55% correct
Diet Coke(n=52), 1 can	7	24	13	8	60% correct	46% correct
Isotonic sports drink(n=52) 500 mL	15	23	6	8	12% correct	12% correct
Sprite(n=50), 1 can	6	23	5	16	10% correct	10% correct
Red Bull(n=52), 1 can	33	7	2	10	76% correct	63% correct
Red Bull sugar - free(n=52), 1 can	27	11	4	10	74% correct	52% correct
Protein shake(n=51), 450ml	4	18	13	16	43% correct	35% correct
Black tea(n=50), 1 cup	10	19	4	17	58% correct	38% correct
Iced tea(n=50), 16 oz/500 mL	3	19	12	16	44% correct	38% correct
ProPlus(n=49), 2 tablets	26	6	0	17	65% correct	53% correct
Instant coffee(n=50), 1 tsp powder	32	13	1	4	90% correct	64% correct
Ground coffee(n=49), 1 scoop brewed	34	8	0	7	85% correct	69% correct
Iced coffee(n=50), 600 mL	32	12	1	5	88% correct	64% correct
Orange juice(n=50), 16 500 mL	4	8	29	9	58% correct	58% correct
Monster(n=52),1 can, 500 ml	30	11	4	7	79% correct	58% correct
Water(n=52),500ml	0	0	45	7	87% correct	87% correct
Milk chocolate(n=49), 40 g bar	3	21	17	8	49% correct	43% correct
Dark chocolate(n=50), 40 g bar	7	23	10	10	60% correct	46$ correct
Cereal bar(n=51), 35 g	0	4	34	13	67% correct	67% correct
Overall % correct (mean)					62%	58%
Standard Deviation					23%	18%

- Correct answers highlighted yellow.

Table 3 Perceptions of effect of caffeine on performance

	Strongly Negative	Negative	Unsure	Positive	Strongly positive	No effect
Endurance(n=52)	0	5	10	20	2	15
Speed (n=52)	0	1	13	18	1	19
Power (n=51)	0	2	11	18	1	19
Strength (n=51)	0	1	17	14	4	15
Concentration (n=52)	2	4	7	24	9	6
Reactions (n=52)	0	1	12	24	10	5
Calmness (n=52)	7	10	13	9	5	8
Fat loss (n=52)	3	3	12	14	1	19

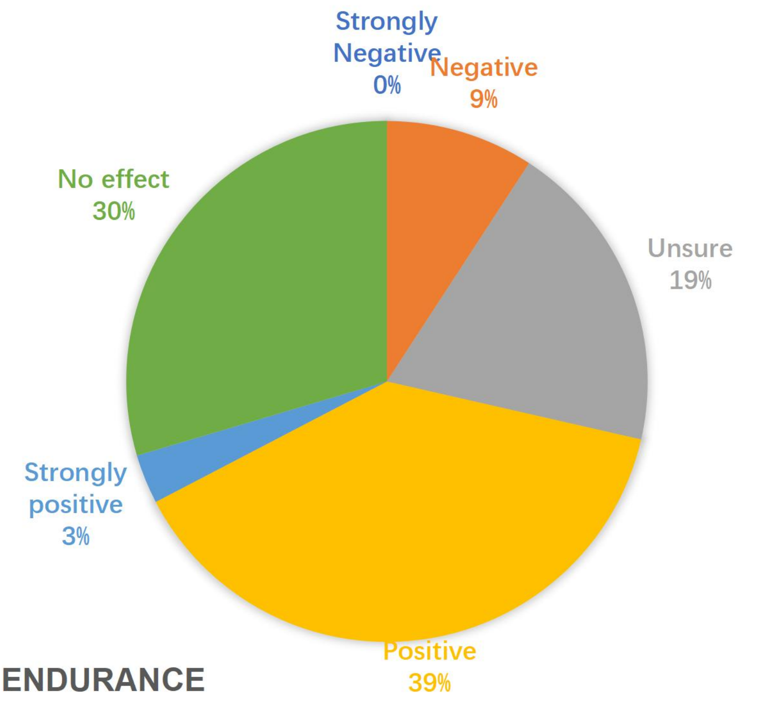


FIGURE 1 ENDURANCE

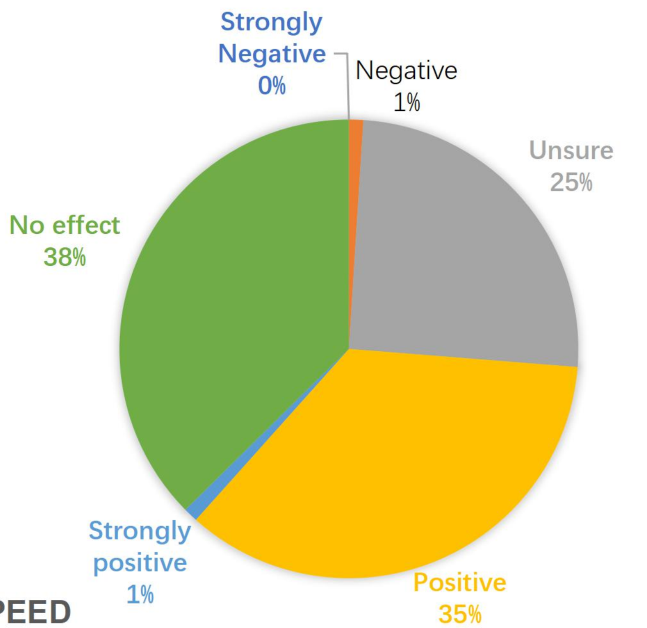


FIGURE 2 SPEED

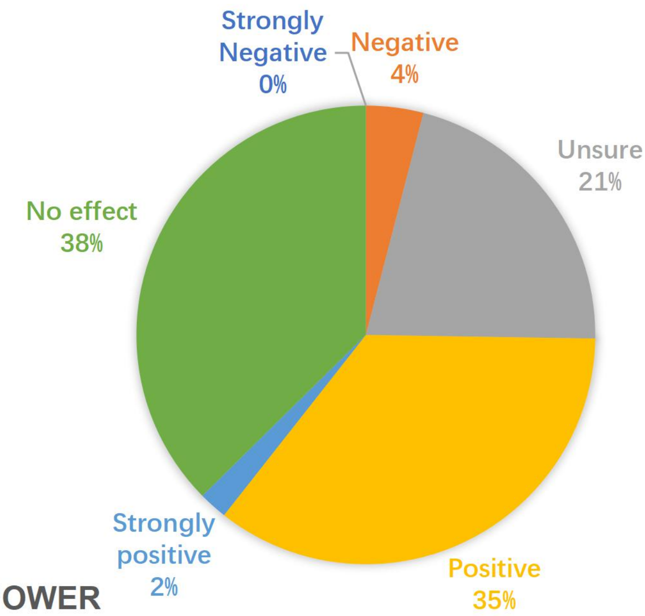


FIGURE 3 POWER

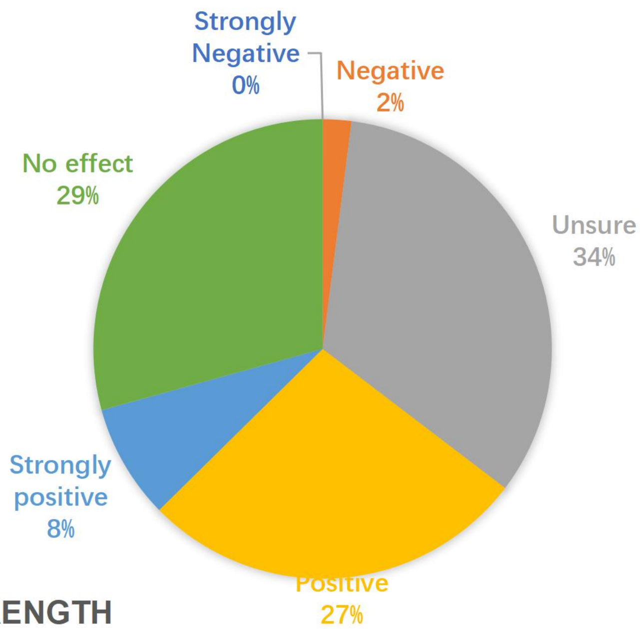


FIGURE 4 STRENGTH

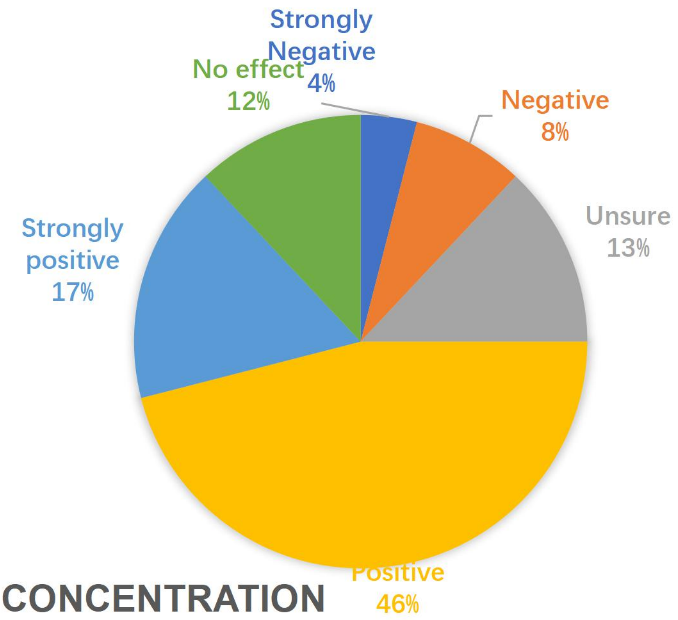


FIGURE 5 CONCENTRATION

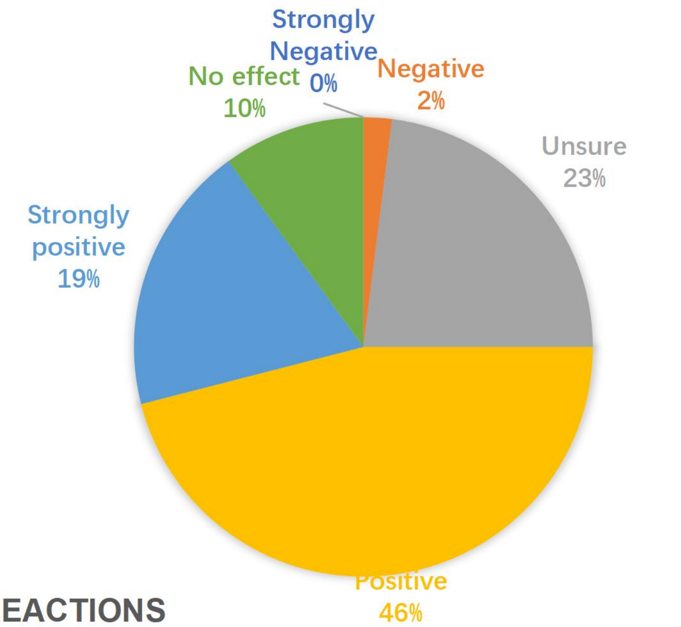


FIGURE 6 REACTIONS

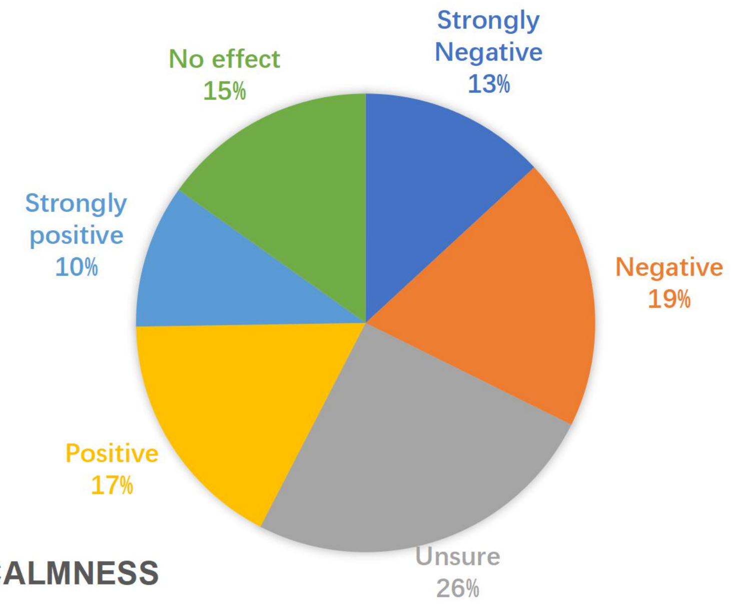


FIGURE 7 CALMNESS

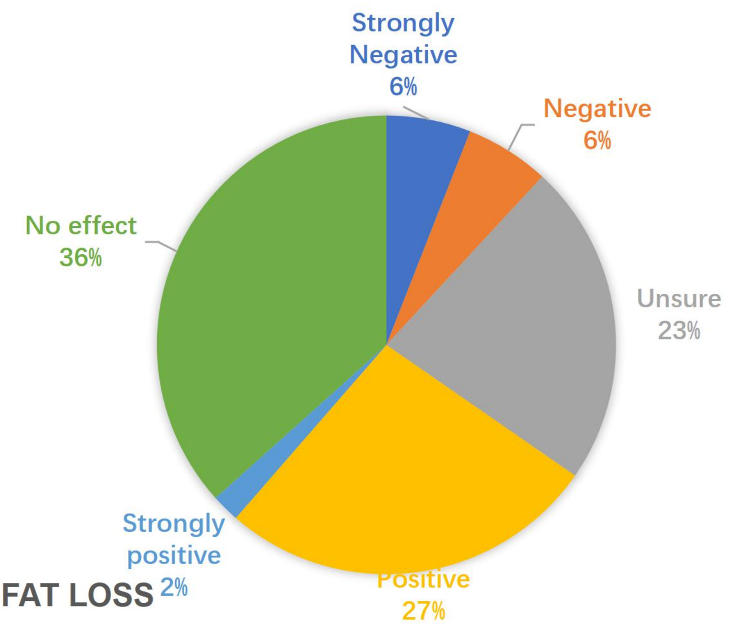


FIGURE 8 FAT LOSS

In terms of endurance （see Figure 1） , only 39% and 3% of athletes believe that caffeine can improve endurance in positive and strongly positive way, although 30% of athletes believe that there is no substantial improvement. In terms of speed (see Figure 2) , 38% of the people think caffeine has no effect and 35% think that caffeine has a positive effect on speed. In terms of Power (see Figure 3) , 35% of the people believe caffeine to be positive, and 38% said it has no effect. In terms of Strength （see Figure 4） , 27% of the people said it has a positive effect, and 28% believed that the caffeine has no effect. 34% of athletes showed unsure attitude， Figure 5 also shows the response of Concentration. 46% of athletes believe caffeine has a positive effect, 17% a strongly positive effect, and 12% no effect. For reaction （see Figure 6） , 46% and 19% of athletes reported that they think caffeine has positive and strongly positive effects, and only 10% expressed no effect. 23% of athletes expressed uncertainty. For calmness (see Figure 7) , 26% of the people were not sure whether it has an effect, 19% suggested a negative effect, and 17% a positive effect. For fat loss（Figure 8）, 36% of people think there is no effect, 27% think there is a positive effect, and 23% are uncertain.

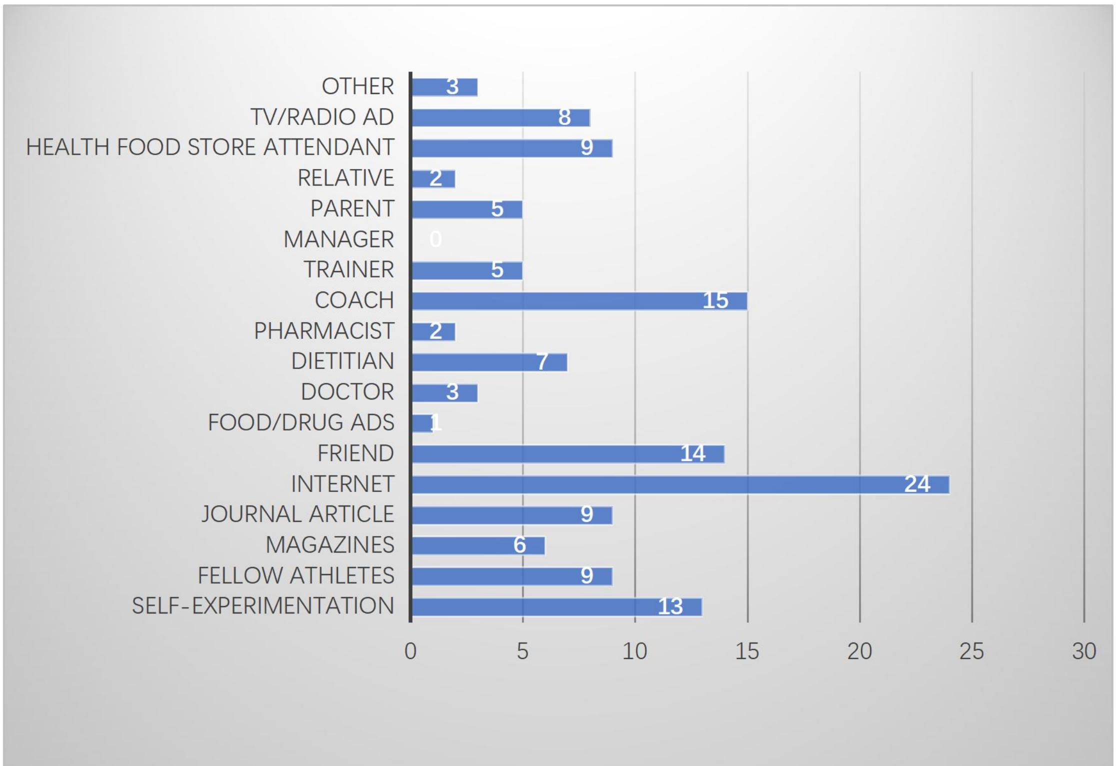


Figure 9 Sources of information on Caffeine and Exercise

For the question on sources of information (see Figure 9), a large number of people use the Internet (46%, n=52), followed by coaches (29%), friends (27%), and Self-experimentation (25%). For the question on caffeine dosage for beneficial effects, 50% of athletes reported a required intake of 50-100 mg, 9% of athlete said less than 50 mg, and 9% of athlete recommended caffeine intake higher than 300 mg. 27% of athletes do not recommend caffeine intake.

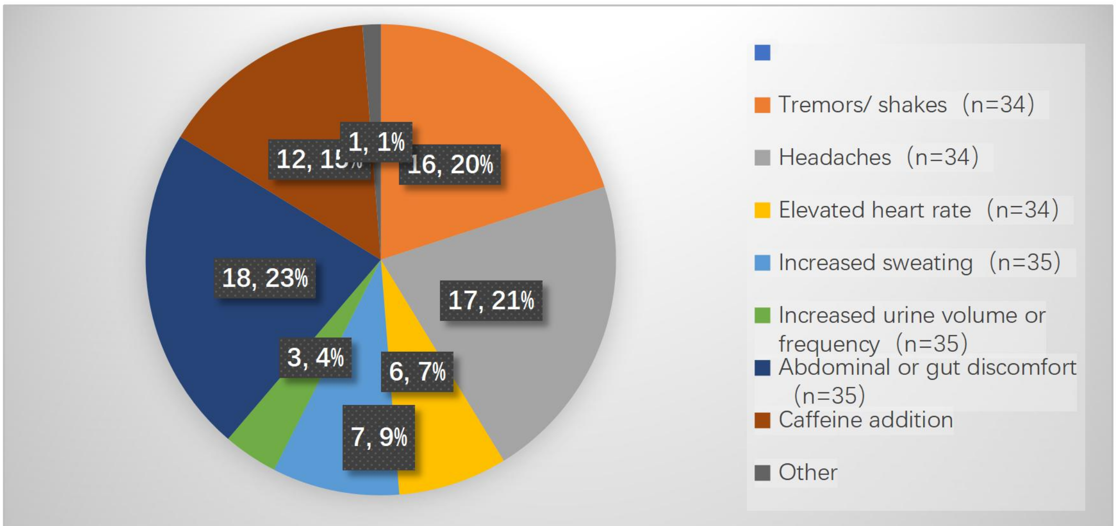


Figure 10 Frengency and Severity of side effects

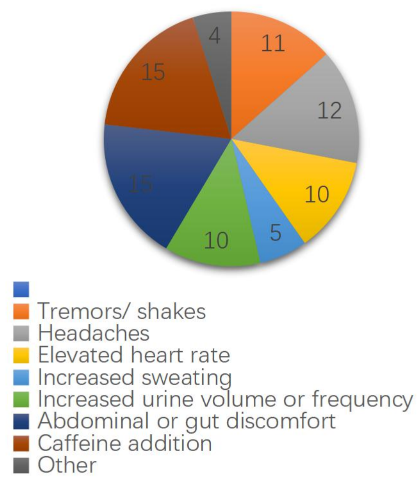


Figure 11: If you do use caffeine for exercise, have you ever experienced any side-effects

The adverse reactions/side-effects reported were; Headaches (50%, n=34, occasionally), Abdominal or gut discomfort (51%, n=35, occasionally), tremors/shakes (47%, n =34, occasionally). The most common side effects were considered to be of low severity because the responses provided by the athletes were 'Barely noticeable'. Only 2 (5%) athletes reported a significant increase in heart rate, and 1 (2%) athletes reported significantly increased urine volume or frequency. In the recent history of caffeine intake, 16 athletes (30%, n=52) are still consuming caffeine, and 26 athletes (50%) do not consume caffeine. Ten athletes (19%) currently do not consume caffeine but have a history of consuming caffeine in the past.

Data correlation

The correlation between age and perceptions of caffeine's effects on performance.

Table 6 Correlation between age and perceptions of caffeine's effects

Variable	P value
Endurance	< 0.001
Speed	0.355
Power	0.029
Strength	0.087
Concentration	0.002
Reactions	0.093
Calmness	0.004
Fat loss	0.333

The correlation between age and perceptions of caffeine ' s effects on performance are summarized in table 6 (and the full results can be found in Annex 3). It can be seen from Table 6 that the relationship between age and perceptions of effect on Endurance is examined. As can be seen from the above table, there is a significant correlation in 'endurance' between age and Endurance performance responses in the questionnaire (P=0.000,P < 0.001). In total 13% of UK-based athletes responded that there is a positive effect for Endurance (67% for the 19-22 age group and 33%% for the 23-27 age group). In total 87% of China-based athletes responded that there is a positive effect for Endurance (16%

for the 19-22 age group and 84%% for the 23-27 age group).

There is a significant correlation between age and Power performance responses in the questionnaire (P = 0.029). It can be seen that a total of 37% of athletes reported an improvement in power, and 32% of athletes were in the 19-22 year old stage and reported an improvement in power. 43% of athletes who are 23-27 years old report an improvement in power.

There is a significant correlation between age and Concentration responses in the questionnaire (P = 0.002). It can be seen that a total of 63% of athletes reported increased concentration. Among them, 29% of athletes reported improvement in the age group 19-22. Between the ages of 23-27, 43% of athletes reported improvement. Of the total number of people selected as "positive" and "very positive", a total of 43% of British athletes replied that concentration has a positive effect (75% in the 19-22 age group and 23-27 age group 25%). A total of 75% of Chinese athletes replied that endurance has a positive effect (10% in the 19-22 age group and 90% in the 23-27 age group). A total of 26% of athletes reported an improvement in their sense of calmness, of which 10% of the total number of athletes reported an improvement in the age group of 19-22 years old, and 47% of athletes between 23-27 years old said that there was some improvement. Of the total number of people selected as "positive" and "very positive", in total 17% of UK-based athletes responded that there is a positive effect for calmness (60% for the 19-22 age group and 40% for the 23-27 age group). In total 34% of China-based athletes responded that there is a positive effect for calmness (22% for the 19-22 age group and 78% for the 23-27 age group).

There is a significant correlation between age and calmness responses in the questionnaire (P = 0.004). A total of 26% of athletes reported an improvement in their sense of calmness, of which 10% of the total number of athletes reported an improvement in the age group of 19-22 years old, and 47% of athletes between 23-27 years old said that there was some improvement. Of the total number of people selected as "positive" and "very positive", in total 17% of UK-based athletes responded that there is a positive effect for calmness (60% for the 19-22 age group and 40% for the 23-27 age group). In total 34% of China-based athletes responded that there is a positive effect for calmness (22% for the 19-22 age group and 78% for the 23-27 age group).

There is no correlation for speed, reactions, strength, fat loss.

Table 7 Correlation between training history and caffeine intake

Variable	P value
Years	0.867

Correlation between training history and caffeine intake are summarized in table 7 (and the full results can be found in Annex 3). As can be seen in Table 14, the relationship between training history and caffeine use is studied. It can be seen from the above table that there is no significant relationship between training history and caffeine use (P=0.867>0.05).

Table 8 Caffeine intake between UK and China-based players.

Variable	P value
Country	0.102

Correlation between caffeine intake between UK and China-based players are summarized in Table 8 (and the full results can be found in Annex 3). As can be seen in Table 15, there is no significant relationship between China users and UK users(P=0.102>0.05).

Table 9 Correlation between athletes performance levels and perceptions of caffeine effects.

Variable	P value
Endurance	< 0.001
Speed	0.629
Power	0.571
Strength	0.055
Concentration	0.907
Reactions	0.025

Calmness	0.252
Fat loss	0.451

Correlation between athletes performance levels and perceptions of caffeine effects are summarized in table 9 (and the full results can be found in Annex 3). It can be seen from Table 9 that there is a significant correlation between highest performance level and endurance performance responses in the questionnaire ($P < 0.001$). It can be seen that a total of 22 athletes reported as "positive" and "strongly positive", accounting for 42% of the total (among these athletes, 13 represent the national team (25% of the total) and 9 represent the university team (accounting for 17% of the total).

There is a significant relationship between performance level and reactions responses in the questionnaire ($P = 0.025$). It can be seen that a total of 31 athletes were reported as "positive" and "strongly positive", accounting for 60% of the total (among them, 7 were from the national team (22.5% of the total) and 24 from the university teams (accounting for the total 77%).

There is no correlation in speed, power, strength, concentration, calmness and fat loss.

Table 10 Percentage positive response in caffeine users and non-users for each performance domain

	Caffeine user	Do not use caffeine
Endurance	48%	40%
Speed	38%	32%
Power	33%	42%
Strength	43%	32%
Concentration	71%	56%
Reactions	67%	64%
Calmness	33%	24%
Fat loss	24%	32%

Table 10 shows that caffeine users tend to report positive effects at a higher rate than non-users..

Discussion

The main purpose of this thesis was to study the knowledge and experience of using sports supplements and ergogenic aids in basketball players, with further/detailed focus on caffeine. The main findings indicate that basketball players lack basic knowledge about some aspects of sports supplements and caffeine supplementation. Previous research has shown that sports supplements are very commonly used in today's society, and their scope and uses are becoming more and more extensive (Colls, 2015), although not all sports supplements on the market have been proven to be effective (both for performance enhancement and safety reasons). The majority of participants in the present study stated that they did not consume sports supplements, which differs from the rates reported in the general population and more widely in other sports (Desbrow and Levertii, 2007; Jovanov et al., 2019; Maughan, 2018). Although sports supplements have certain safety issues (Vitale, 2009), the subjects in the questionnaire also knew this. Chinese athletes mainly refer to coaches when taking sports supplements (100%), while British athletes stated that they do not consume sports supplements (47%, n = 52); or from "self-learning" information (52%, n = 52). As for Chinese athletes, 46% (n=52) of athletes choose to take sports supplements, which is close to the number of British athletes. As for the reasons for not using sports supplements, Chinese athletes stated that they do not know enough about sports supplements (72%) and for British only 23% gave this response. This suggests that British athletes have much more confidence in their knowledge about sports supplements than Chinese athletes. In the selection of sports supplements, a high proportion of Chinese athletes (48%) seemed to focus on performance, whilst the number of British athletes selecting this option was 20%. In the dosage of exercise supplements, most subjects conducted their own research (21%, n = 52). However, 48% of the subjects chose not to consume sports supplements. Through questionnaire surveys, British athletes do not seem to use sports supplements often. This seems to be related to the reason that they did not consume sports supplements from the questionnaire. On the one hand, the participants believed that the safety of sports supplements caused them not to consume sports supplements. On the other hand, it might be due to lack of professional support to guide their use (Froiland,2004). However, athletes taking sports supplements report that their performance and recovery are the most common reason for doing so. Sports supplements have now become an indispensable part of modern sports and have broad prospects for development (Hoyte,2013). The proportion of athletes who choose not to consume sports supplements (63%) is also very high. The main reason for not taking supplements is basically that they do not know much (54%). Such research results have also been confirmed in other studies (Nieper, 2005). However, only 20% of the athletes in that study choose to consume sports supplements. It seems that college students do not know much about sports supplements and their effects, which leads to fewer people using them. This may suggest that college students do not know much about sports supplements and their effects, which leads to fewer people taking them. This may help to explain the findings of the present study, where the low general use was contrary to the results of previous studies on use in athletes, as the athletes in the current study were in this demographic/age group (i.e. University students). However, people must carefully understand the supplements used before taking it. Appropriate consumption of sports supplements can improve game performance, but it is still necessary to work hard to understand whether supplements are appropriate (Maughan, 2018). Since the subjects within this thesis are not Olympic-level athletes, it is less likely that they receive national sports science services compared to higher-level athletes. The staffing of university-level sports teams and national-level sports teams is very different. The training team and management mode of national sports teams are much higher than those of university sports teams. Members of college basketball teams tend to conduct their own research on the use of sports supplements. Compared with British basketball players, more Chinese basketball players had a history of consuming supplements (78% in China and 22% in the UK) and caffeine intake (62% in China and 38% in the UK). Most Chinese basketball players are national level two players. Whereas most of the British players were from the University team, all Chinese basketball players are at the D1 level, while British basketball players are basically at the D3 level. Since there is no literature on the effects of sports supplements on athletes of different levels, this study provides additional information that is not currently available in the existing literature. Since there are no professional personnel to guide athletes, the applicability of the research results of this study to a wider range of basketball players is limited.

Another finding of this thesis is that subjects' ability to accurately assess the caffeine content of these foods was not so accurate. For non-traditional caffeine-containing foods, such as the caffeine content of caffeine-containing drugs in subjects, their accuracy is not high. For non-caffeine foods, especially Sprite, Isotonic sports drink, the accuracy is very low. For some of these products, the nutrient content, but not the caffeine content, is shown on the label and this could be a contributing factor in some cases. The results show that, generally speaking, athletes are more accurate at confirming whether caffeine is contained in foods, but less accurate when it comes to classifying them as high (> 50 mg per serving) or low (< 50 mg) content. It may be that they would not specifically check the ingredients and content on the label before ingesting these foods. The most surprising finding is that the correctness of the caffeine content of the two options of water and orange juice is 87% and 58% and that 9 and 7 athletes, respectively, stating they were unfamiliar with these items. This is difficult to understand. It may be because the subjects did not answer the questionnaire properly, or did not fully understand the question. It is worthy of note that there were no translation issues with these items for the Chinese athletes. However, Desbrow and Leveritt (2007), also had similar findings for orange juice in elite Ironman triathletes, whereby 7% responded as unfamiliar with this item. In addition, Desbrow and Leveritt (2007) also showed similar findings to the present study, whereby accuracy of identifying caffeine containing items that are well known (or heavily marketed) for this (such as energy drinks) was high, but accuracy on caffeine content, and precise amounts (high vs low) in common foods was much lower.

Another finding of this thesis (e.g. Tables 15-22) is that caffeine is believed to have beneficial effects on Endurance, Power, Calmness, and Concentration after ingestion, which agrees with previous research on physical and cognitive performance, although the perceptions on benefits calmness are more difficult to understand, and perhaps highlight the limitations with assessing this retrospectively in a questionnaire like this (Heyes, 1988, Del Coso, 2008, Cappelletti, 2015). In terms of Endurance, caffeine intake can improve short-term endurance effects （Bruce， 2000). In ball sports, caffeine has been shown to enhance numerous aspects of performance. Chia et al. (2017) conducted a comprehensive review on caffein in ball sport athletes, and identified that 8 of 10 studies found beneficial effects on sprint performance, and 7 of 8 studies reported beneficial effects on vertical jump performance. And it is consistent with the argument in Grigic (2018) that caffeine intake will significantly increase muscle power and strength. And there is a potential improvement for concentration (Cappelletti, 2015). But there is very little research on calmness, and long-term research is needed. However, through Table 5-12, we can find that the number of athletes who have positive perceptions about caffein's effects on speed (35%) and reaction (46%) accounts for a large proportion. It may be related to the intake, which may be due to the fact that the athletes fill in the questionnaire by means of recall, which is vague about the real situation, but does not rule out the real situation. However, only 31% of people in this paper are ingesting caffeine, and 50% of people have a history of caffeine intake, which may also influence this finding.. Similarly, for the answer to the question of the recommended intake of caffeine, previous research commonly uses doses of 6 9mg/kg caffeine (or above) showing beneficial effects on many coimnpoennts of performance (Tucker, 2013) (Stedheim, 2014) (Spriet, 2014) (San, 2019). There are also many low-dose caffeine intakes (3 mg/kg, even lower than 2mg/kg) that have also shown benefits (Graham, 1995. Cox, 2002. Burke, 2008). However, in the questionnaire, only 23% of the athletes answered the recommended amount of caffeine intake, while 42% of the athletes responded with a certain degree of research. It seems that the participants in this paper do not know much about the potential relationship between dose and effects on performance. In addition, in Attwood et al. (2007) individuals with high habitual caffeine intake were shown to have enhanced reaction time after a 400 mg dose of caffeine, while the moderate caffeine consumers did not have a positive effect, showing that individual differences and/or habitual use may influence how people respond due to differences in metabolism and/or sensitivity （Clarke, 2020). But this point seems to be challenged by some studies. In addition, there is a high possibility of selection/response bias, whereby those who are high users do so because of their beliefs in the beneficial effects.

Another finding shows the Internet（46%）, have become their main sources of information on caffeine's effects, follwoed by Coaches（29%）, friends（27%）, and self-experimentation（25%） This may also be due to the fact that the staffing of university teams cannot be equipped with professional sports science teams (Froiland， 2004) like national sports teams, which leads to different sources of information. Most young athletes mainly listen to the advice of coaches (Jovanov, 2019, Diehl, 2012), but this can be expected, because semi-professional or professional athletes are very dependent on coaches, and are very different from their own. Teammates spend a lot of time with each other, although it takes more time to listen to coach's suggestions and friends' suggestions than from their own experience（Jovanov, 2019）. On the other hand, it is not surprising that the Internet has become the main source of information. The emergence of this same problem requires the implementation of an education program on sports supplements. It is worth discussing that many coaches have insufficient knowledge of sports supplements, and they are not enough to provide correct advice to consume sports supplements (McGehee, 2012). Compared with Niper (2005), 75% of athletes have access to dietitians. As a result, the athletes in this article have a lower rate of exposure to nutritionists (9%). The reason for this may be that the university cannot reach the service team that enjoys the national team or the athlete is not familiar with the advice provided by the nutritionist. And for the side effects caused by caffeine, related experiments have concluded that the subjective effects of caffeine on the two groups of people who consume caffeine tend to be positive, while those who do not take caffeine have a positive effect on coffee. The effect of the cause is mostly negative (Evans, 1992). The answer to the question of the influence of this psychological element on the side effects of caffeine cannot be ruled out. The subjects responded positively to the side effects of caffeine in Table 8. For athletes with serious physical adverse reactions, the increased heart rate and caffeine addiction may be caused by their own factors （such as gastrointestinal discomfort, different food intake, etc.) (Reyes, 2018). However, the answer to the side effects in this paper is not very serious. Many subjects did not feel very strongly about the side effects of caffeine, and this article did not discuss very serious side effects. The research results of Desbrow (2007) also reported that there are few side effects caused by taking caffeine during exercise. Based on the results of the side effects obtained in this paper, it seems that the negative effects of caffeine on college students do not appear often.

In a research report by Chiba (2015), it was reported that 70.3% of patients took dietary supplements and drugs at the same time without consulting a professional doctor. These subjects believed that dietary supplements were completely safe. Only 8.4% of the subjects believed that dietary supplements had certain potential side effects or risks. And since 1996, there has been a way to buy special anabolic androgenic steroids, the so-called hormones, in the sports nutrition market. Such substances are advertised as having the effect of promoting muscle growth. Also according to WADA regulations, such substances are included in the banned list of anabolic agents（Geyer，2008). In a previous study (Hoyte, 2013), 64% of college students had a history of using sports supplements, but they did not know much about the safety of sports supplements. Regardless of whether it is the safety of sports supplements or the safety of caffeine, many athletes cannot effectively distinguish whether there is caffeine in the some common products through the above problems, and the content of caffeine is not correct. For these athletes, it is necessary to better understand the ingredients and caffeine content of food/beverages/common products used in daily life (likewise, this could be an issue for athletes who want to avoid caffeine- further understanding is needed to avoid accidentally ingesting foods containing caffeine). In addition, information on the caffeine content of various foods consumed by athletes is needed for athletes to consume according to their own conditions. If you monitor the physical data of athletes, you should also educate athletes on the negative effects of caffeine, especially the adverse effects and reactions of excessive use. Since caffeine was removed from the WADA's banned substances list in 2004, the test of the urine caffeine concentration of athletes found that the use of caffeine has increased slightly, and individual sports (especially endurance) athletes are more inclined in competitions of using caffeine (Aguailar,2015). However, this is probably because of the clear and well-documented benefits that are evident in this type of activity (Burke, 2008; Spriet, 2014). For the education of basketball players in universities, the following measures can be taken: Athletes widely use dietary supplements in sports, but long-term use will bring certain health risks. And there is a potential violation of WADA's doping regulations. Athletes will be punished for inadvertently ingesting contaminated dietary supplements（Maughan，2004）. So as to improve the sports performance of the college team, especially the lower-level college basketball team, but there is no guarantee that the consumption of caffeine or sports supplements will be a decisive factor in the final game result. Nowadays, there are not many caffeine studies on team events. There are more studies on elite basketball players than on college basketball players. Therefore, more recent studies are needed to help lower-level college sports teams to improve. Combined with the usual training, the use of sports supplements and the proper use of caffeine in competitions, you can get better sports performance. At the same time, the most basic caffeine knowledge also needs further study.

Limitations

Most of the research participants in this thesis cannot be regarded as national elite basketball players, meaning these findings are not generalizable to such populations. However, there is a gap in the literature for college level athletes, and this study provides important information applicable to this population. And due to the impact of COVID-19, the originally planned human experiment could not be carried out, and the test method was changed to a questionnaire survey method. For example, the side effects of the body after ingesting caffeine may be more accurate than the body reactions recorded in actual human experiments. The side effects of caffeine in this article are based on the subjects' past experience, and the accuracy might not be very high. In addition, athletes may not answer the questionnaire correctly. In addition, the questionnaire for Chinese athletes is translated from English into Chinese, and there may be some deviations between Chinese and English in the direct meaning of some questions.

Conclusion

Caffeine (25%) and sports supplements (37%) were not used as much as expected among college students. The main motivations for athletes who did use them were to improve athletic performance (35%) and recovery (32%). The Internet (46%) and coaches (29%) were the main sources of information for athletes. The side effects of caffeine seem to have minimal impact on college athletes. However, athletes displayed poor knowledge on the content of caffeine in some foods/products. Athletes at the competitive level must understand the WADA regulations (Jovanov, 2019). Although the subjects of this paper are not Olympic-level athletes, they may also benefit from further education on the basics of caffeine and sports supplements.

Reference

Abian, P., Del Coso, J., Salinero, J., Gallo-Salazar, C., Areces, F., Ruiz-Vicente, D., Lara, B., Soriano, L., Muñoz, V. and Abian-Vicen, J., 2014. The ingestion of a caffeinated energy drink improves jump performance and activity patterns in elite badminton players. *Journal of Sports Sciences*, 33(10), pp.1042-1050.

Abian-Vicen, J., Puente, C., Salinero, J., González-Millán, C., Areces, F., Muñoz, G., Muñoz-Guerra, J. and Del Coso, J., 2014. A caffeinated energy drink improves jump performance in adolescent basketball players. *Amino Acids*, 46(5), pp.1333-1341.

Aguilar-Navarro, M., Muñoz, G., Salinero, J., Muñoz-Guerra, J., Fernández-Álvarez, M., Plata, M. and Del Coso, J., 2019. Urine Caffeine Concentration in Doping Control Samples from 2004 to 2015. Nutrients, 11(2), p.286.

Attwood, A., Higgs, S. and Terry, P., 2006. Differential responsiveness to caffeine and perceived effects of caffeine in moderate and high regular caffeine consumers. Psychopharmacology, 190(4), pp.469-477.

Ben Abdelkrim, N., Castagna, C., El Fazaa, S. and El Ati, J., 2010. The Effect of Players' Standard and Tactical Strategy on Game Demands in Men's Basketball. *Journal of Strength and Conditioning Research*, 24(10), pp.2652-2662.

Ben Abdelkrim, N., El Fazaa, S., El Ati, J. and Tabka, Z., 2007. Time-motion analysis and physiological data of elite under-19-year-old basketball players during competition * Commentary. *British Journal of Sports Medicine*, 41(2), pp.69-75.

Bond, P., Llewellyn, W. and Van Mol, P., 2016. Anabolic androgenic steroid-induced hepatotoxicity. Medical Hypotheses, 93, pp.150-153.

Bridge, C. and Jones, M., 2006. The effect of caffeine ingestion on 8 km run performance in a field setting. *Journal of Sports Sciences*, 24(4), pp.433-439.

BRUCE, C., ANDERSON, M., FRASER, S., STEPTO, N., KLEIN, R., HOPKINS, W. and HAWLEY, J., 2000. Enhancement of 2000-m rowing performance after caffeine ingestion. *Medicine & Science in Sports & Exercise*, 32(11), pp.1958-1963.

Burd, N., Yang, Y., Moore, D., Tang, J., Tarnopolsky, M. and Phillips, S., 2012. Greater stimulation of myofibrillar protein synthesis with ingestion of whey protein isolate v. micellar casein at rest and after resistance exercise in elderly men. British Journal of Nutrition, 108(6), pp.958-962.

Burke LM. Caffeine and sports performance. Appl Physiol Nutr Metab. 2008 Dec;33(6):1319-34. doi: 10.1139/H08-130. PMID: 19088794.

Campbell, B., Kreider, R., Ziegenfuss, T., La Bounty, P., Roberts, M., Burke, D., Landis, J., Lopez, H. and Antonio, J., 2007. International Society of Sports Nutrition position stand: protein and exercise. *Journal of the International Society of Sports Nutrition*, 4(1), p.8.

Cappelletti, S., Daria, P., Sani, G. and Aromatario, M., 2015. Caffeine: Cognitive and Physical Performance Enhancer or Psychoactive Drug?. *Current Neuropharmacology*, 13(1), pp.71-88.

Cappelletti, S., Piacentino, D., Fineschi, V., Frati, P., Cipolloni, L. and Aromatario, M., 2018. Caffeine-Related Deaths: Manner of Deaths and Categories at Risk. *Nutrients*, 10(5), p.611.

Carswell, A. T., Howland, K., Martinez-Gonzalez, B., Baron, P., & Davison, G. (2020). The effect of caffeine on cognitive performance is influenced by CYP1A2 but not ADORA2A genotype, yet neither genotype affects exercise performance in healthy adults. European journal of applied physiology, 120(7), 1495–1508. https://doi.org/10.1007/s00421-020-04384-8

Castagna, C. and Castellini, E., 2013. Vertical Jump Performance in Italian Male and Female National Team Soccer Players. *Journal of Strength and Conditioning Research*, 27(4), pp.1156-1161.

Chia, J., Barrett, L., Chow, J. and Burns, S., 2017. Effects of Caffeine Supplementation on

Performance in Ball Games. *Sports Medicine*, 47(12), pp.2453-2471.

Chiba, T., Sato, Y., Suzuki, S. and Umegaki, K., 2015. Concomitant Use of Dietary Supplements and Medicines in Patients due to Miscommunication with Physicians in Japan. *Nutrients*, 7(4), pp.2947-2960

Chou, T. M., & Benowitz, N. L. (1994). Caffeine and coffee: effects on health and cardiovascular disease. Comparative biochemistry and physiology. Part C, Pharmacology, toxicology & endocrinology, 109(2), 173–189.

Clarke, N. D., & Richardson, D. L. (2020). Habitual Caffeine Consumption Does Not Affect the Ergogenicity of Coffee Ingestion During a 5 km Cycling Time Trial. *International journal of sport nutrition and exercise metabolism,* 1–8. Advance online publication. https://doi.org/10.1123/ijsnem.2020-0204

Colls Garrido C, Gómez-Urquiza JL, Cañadas-De la Fuente GA, Fernández-Castillo R. USO, EFECTOS Y CONOCIMIENTOS DE LOS SUPLEMENTOS NUTRICIONALES PARA EL DEPORTE EN ESTUDIANTES UNIVERSITARIOS [USE, EFFECTS, AND KNOWLEDGE OF THE NUTRITIONAL SUPPLEMENTS FOR THE SPORT IN UNIVERSITY STUDENTS]. Nutr Hosp. 2015 Aug 1;32(2):837-44. Spanish. doi: 10.3305/nh.2015.32.2.8057. PMID: 26268119.

Cornelis MC, El-Sohemy A, Campos H. Genetic polymorphism of the adenosine A2A receptor is associated with habitual caffeine consumption. Am J Clin Nutr. 2007 Jul;86(1):240-4. doi: 10.1093/ajcn/86.1.240. PMID: 17616786.

Conte, D., Favero, T., Lupo, C., Francioni, F., Capranica, L. and Tessitore, A., 2015. Time-Motion Analysis of Italian Elite Women's Basketball Games. *Journal of Strength and Conditioning Research*, 29(1), pp.144-150.

Cox, G., Desbrow, B., Montgomery, P., Anderson, M., Bruce, C., Macrides, T., Martin, D., Moquin, A., Roberts, A., Hawley, J. and Burke, L., 2002. Effect of different protocols of caffeine intake on metabolism and endurance performance. *Journal of Applied Physiology*, 93(3), pp.990-999.

DEL COSO, J., ESTEVEZ, E. and MORA-RODRIGUEZ, R., 2008. Caffeine Effects on Short-Term Performance during Prolonged Exercise in the Heat. *Medicine & Science in Sports & Exercise*, 40(4), pp.744-751.

Del Coso, J., Muñoz-Fernández, V., Muñoz, G., Fernández-Elías, V., Ortega, J., Hamouti, N., Barbero, J. and Muñoz-Guerra, J., 2012. Effects of a Caffeine-Containing Energy Drink on Simulated Soccer Performance. *PLoS ONE*, 7(2), p.e31380.

Del Coso, J., Portillo, J., Muñoz, G., Abián-Vicén, J., Gonzalez-Millán, C. and Muñoz-Guerra, J., 2013. Caffeine-containing energy drink improves sprint performance during an international rugby sevens competition. Amino Acids, 44(6), pp.1511-1519.

Delextrat, A. and Cohen, D., 2008. Physiological Testing of Basketball Players: Toward a Standard Evaluation of Anaerobic Fitness. *Journal of Strength and Conditioning Research*, 22(4), pp.1066-1072.

Desbrow, B. and Leveritt, M., 2007. Well-Trained Endurance Athletes' Knowledge, Insight, and Experience of Caffeine Use. *International Journal of Sport Nutrition and Exercise Metabolism*, 17(4), pp.328-339.

Docherty, J., 2008. Pharmacology of stimulants prohibited by the World Anti-Doping Agency (WADA). *British Journal of Pharmacology*, 154(3), pp.606-622.

DUVNJAK-ZAKNICH, D., DAWSON, B., WALLMAN, K. and HENRY, G., 2011. Effect of Caffeine on Reactive Agility Time When Fresh and Fatigued. *Medicine & Science in Sports & Exercise*, 43(8), pp.1523-1530.

Diehl, K., Thiel, A., Zipfel, S., Mayer, J., Schnell, A., & Schneider, S. (2012). Elite adolescent athletes' use of dietary supplements: characteristics, opinions, and sources of supply and information. *International journal of sport nutrition and exercise metabolism*, 22(3), 165–174. https://doi.org/10.1123/ijsnem.22.3.165

Eliason, M., Eichner, A., Cancio, A., Bestervelt, L., Adams, B. and Deuster, P., 2012. Case Reports: Death of Active Duty Soldiers Following Ingestion of Dietary Supplements Containing 1,3-Dimethylamylamine (DMAA). *Military Medicine*, 177(12), pp.1455-1459.

el-Guebaly, N., Carra, G. and Galanter, M., 2015. Textbook Of Addiction Treatment： Addiction to Caffeine and Other Xanthines.

Evans, S. and Griffiths, R., 1992. Caffeine tolerance and choice in humans. Psychopharmacology, 108(1-2), pp.51-59.

Froiland, K., Koszewski, W., Hingst, J. and Kopecky, L., 2004. Nutritional Supplement Use among College Athletes and Their Sources of Information. International *Journal of Sport Nutrition and Exercise Metabolism*, 14(1), pp.104-120.

Gerald, M., 1978. Effects of (+)-amphetamine on the treadmill endurance performance of rats. *Neuropharmacology*, 17(9), pp.703-704.

Gervasi, M., Sisti, D., Amatori, S., Donati Zeppa, S., Annibalini, G., Piccoli, G., Vallorani, L., Benelli, P., Rocchi, M., Barbieri, E., Calavalle, A., Agostini, D., Fimognari, C., Stocchi, V. and Sestili, P., 2020. Effects of a commercially available branched-chain amino acid-alanine-carbohydrate-based sports supplement on perceived exertion and performance in high intensity endurance cycling tests. *Journal of the International Society of Sports Nutrition*, 17(1).

Geyer, H., Parr, M., Koehler, K., Mareck, U., Schänzer, W. and Thevis, M., 2008. Nutritional supplements cross - contaminated and faked with doping substances. Journal of Mass Spectrometry, 43(7), pp.892-902.

GONGLACH, A., ADE, C., BEMBEN, M., LARSON, R. and BLACK, C., 2016. Muscle Pain as a

Regulator of Cycling Intensity. *Medicine & Science in Sports & Exercise*, 48(2), pp.287-296.

Graham, T., 2001. Caffeine and Exercise. *Sports Medicine*, 31(11), pp.785-807.

Grgic, J., Trexler, E. T., Lazinica, B., & Pedisic, Z. (2018). Effects of caffeine intake on muscle strength and power: a systematic review and meta-analysis. *Journal of the International Society of Sports Nutrition*, *15*, 11. https://doi.org/10.1186/s12970-018-0216-0

Ha, E. and Zemel, M., 2003. Functional properties of whey, whey components, and essential amino acids: mechanisms underlying health benefits for active people (review). *The Journal of Nutritional Biochemistry*, 14(5), pp.251-258.

Heyes, M., Garnett, E. and Coates, G., 1988. Nigrostriatal dopaminergic activity is increased during exhaustive exercise stress in rats. *Life Sciences*, 42(16), pp.1537-1542.

Hoyte, C., Albert, D. and Heard, K., 2013. The Use of Energy Drinks, Dietary Supplements, and Prescription Medications by United States College Students to Enhance Athletic Performance. *Journal of Community Health*, 38(3), pp.575-580.

Jenkins, N., Trilk, J., Singhal, A., O'Connor, P. and Cureton, K., 2008. Ergogenic Effects of Low Doses of Caffeine on Cycling Performance. International Journal of Sport Nutrition and Exercise Metabolism, 18(3), pp.328-342.

Jovanov, P., Đorđić, V., Obradović, B., Barak, O., Pezo, L., Marić, A., & Sakač, M. (2019). Prevalence, knowledge and attitudes towards using sports supplements among young athletes. *Journal of the International Society of Sports Nutrition*, *16*(1), 27.
https://doi.org/10.1186/s12970-019-0294-7

Karnatovskaia, L., Moreno, J. and Freeman, M., 2012. 1153. Critical Care Medicine, 40, pp.1-328.

Kavouras, S., Troup, J. and Berning, J., 2004. The Influence of Low versus High Carbohydrate Diet on a 45-min Strenuous Cycling Exercise. *International Journal of Sport Nutrition and Exercise Metabolism*, 14(1), pp.62-72.

Kim, T., Lee, J., Lee, H. and Lee, S., 2019. Blood dopamine level enhanced by caffeine in men after treadmill running. *Chinese Journal of Physiology*, 62(6), p.279.

Laurent, D., 2000. Effects of Caffeine on Muscle Glycogen Utilization and the Neuroendocrine Axis during Exercise. *Journal of Clinical Endocrinology & Metabolism*, 85(6), pp.2170-2175.

Lim, B., Jang, M., Shin, M., Kim, H., Kim, Y., Kim, Y., Chung, J., Kim, H., Shin, M., Kim, S., Kim, E. and Kim, C., 2001. Caffeine inhibits exercise-induced increase in tryptophan hydroxylase expression in dorsal and median raphe of Sprague–Dawley rats. *Neuroscience Letters*, 308(1), pp.25-28.

Lorino, A., Lloyd, L., Crixell, S. and Walker, J., 2006. The Effects of Caffeine on Athletic Agility. *The Journal of Strength and Conditioning Research*, 20(4), p.851.

Lorist, M. and Tops, M., 2003. Caffeine, fatigue, and cognition. *Brain and Cognition*, 53(1), pp.82-94.

Maughan, R. J., Burke, L. M., Dvorak, J., Larson-Meyer, D. E., Peeling, P., Phillips, S. M., Rawson, E. S., Walsh, N. P., Garthe, I., Geyer, H., Meeusen, R., van Loon, L., Shirreffs, S. M., Spriet, L. L., Stuart, M., Vernec, A., Currell, K., Ali, V. M., Budgett, R. G., Ljungqvist, A., … Engebretsen, L. (2018). IOC consensus statement: dietary supplements and the high-performance athlete. *British journal of sports medicine*, 52(7), pp439–455. https://doi.org/10.1136/bjsports-2018-099027

Maughan, R., 2005. Contamination of dietary supplements and positive drug tests in sport. *Journal of Sports Sciences,* 23(9), pp.883-889.

Murray A, Traylor J. 2020.Caffeine Toxicity.. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK532910/

Nieper A. (2005). Nutritional supplement practices in UK junior national track and field athletes. *British journal of sports medicine*, 39(9), 645–649. https://doi.org/10.1136/bjsm.2004.015842

Nieman, D., 2010.Caffeine Supplementation and Multiple Sprint Running Performance. *Yearbook of Sports Medicine*, 2010, pp.211-212.

Magkos, F. and Kavouras, S., 2005. Caffeine Use in Sports, Pharmacokinetics in Man, and Cellular Mechanisms of Action. *Critical Reviews in Food Science and Nutrition*, 45(7-8), pp.535-562.

Matthew, D. and Delextrat, A., 2009. Heart rate, blood lactate concentration, and time–motion analysis of female basketball players during competition. *Journal of Sports Sciences*, 27(8), pp.813-821.

Maulder, P. and Cronin, J., 2005. Horizontal and vertical jump assessment: reliability, symmetry, discriminative and predictive ability. *Physical Therapy in Sport*, 6(2), pp.74-82.

Pasman, W., van Baak, M., Jeukendrup, A. and de Haan, A., 1995. The Effect of Different Dosages of Caffeine on Endurance Performance Time. *International Journal of Sports Medicine*, 16(04), pp.225-230.

Petróczi, A., Naughton, D., Mazanov, J., Holloway, A. and Bingham, J., 2007. Performance enhancement with supplements: incongruence between rationale and practice. *Journal of the International Society of Sports Nutrition,* 4(1).

Puente, C., Abián-Vicén, J., Salinero, J., Lara, B., Areces, F. and Del Coso, J., 2017. Caffeine Improves Basketball Performance in Experienced Basketball Players. *Nutrients*, 9(9), p.1033.

Pickering, C. and Kiely, J., 2017. Are the Current Guidelines on Caffeine Use in Sport Optimal for Everyone? Inter-individual Variation in Caffeine Ergogenicity, and a Move Towards Personalised Sports Nutrition. *Sports Medicine*, 48(1), pp.7-16.

Pickering, C., & Kiely, J. (2019). What Should We Do About Habitual Caffeine Use in Athletes?. *Sports medicine* (Auckland, N.Z.), 49(6), 833–842. https://doi.org/10.1007/s40279-018-0980-7

Porciúncula, L. O., Sallaberry, C., Mioranzza, S., Botton, P. H., & Rosemberg, D. B. (2013). The Janus face of caffeine. *Neurochemistry international*, 63(6), 594–609. https://doi.org/10.1016/j.neuint.2013.09.009

Reyes, C. and Cornelis, M., 2018. Caffeine in the Diet: Country-Level Consumption and Guidelines. *Nutrients*, 10(11), p.1772.

Rivers, W. and Webber, H., 1907. The action of caffeine on the capacity for muscular work. *The Journal of Physiology*, 36(1), pp.33-47.

Ronis, M., Pedersen, K. and Watt, J., 2018. Adverse Effects of Nutraceuticals and Dietary Supplements. *Annual Review of Pharmacology and Toxicology*, 58(1), pp.583-601.

Salazar Mejía, D. and Fontaine Guevara, L., 2017. USO DE SUPLEMENTOS NUTRICIONALES EN ESTUDIANTES UNIVERSITARIOS. Revista Iberoamericana de Ciencias de la Actividad Física y el Deporte, 6(1).

San Juan, A., López-Samanes, Á., Jodra, P., Valenzuela, P., Rueda, J., Veiga-Herreros, P., Pérez-López, A. and Domínguez, R., 2019. Caffeine Supplementation Improves Anaerobic Performance and Neuromuscular Efficiency and Fatigue in Olympic-Level Boxers. *Nutrients*, 11(9), p.2120.

STUART, G., HOPKINS, W., COOK, C. and CAIRNS, S., 2005. Multiple Effects of Caffeine on Simulated High-Intensity Team-Sport Performance. *Medicine & Science in Sports & Exercise*, 37(11), pp.1998-2005

Scanlan, A., Humphries, B., Tucker, P. and Dalbo, V., 2013. The influence of physical and cognitive factors on reactive agility performance in men basketball players. *Journal of Sports Sciences*, 32(4), pp.367-374.

Spriet, L., 2014. Exercise and Sport Performance with Low Doses of Caffeine. *Sports Medicine*, 44(S2), pp.175-184.

Sökmen, B., Armstrong, L. E., Kraemer, W. J., Casa, D. J., Dias, J. C., Judelson, D. A., & Maresh, C. M. (2008). Caffeine use in sports: considerations for the athlete. *Journal of strength and conditioning research*, 22(3), 978–986. https://doi.org/10.1519/JSC.0b013e3181660cec

STADHEIM, HANS KRISTIAN1; SPENCER, MATTHEW1; OLSEN, RAYMOND2; JENSEN, JØRGEN1., 2014. Caffeine and Performance over Consecutive Days of Simulated Competition, Medicine & Science in Sports & Exercise,46(9), pp. 1787-1796

Swift, C. and Tiplady, B., 1988. The effects of age on the response to caffeine. Psychopharmacology, 94(1), pp.29-31.

Tangen, D., Nielsen, S., Kolnes, K. and Jensen, J., 2020. Caffeine Increases Vertical Jumping Height in Young Trained Males Before But Not After a Maximal Effort Strength Training Session. *Journal of Science in Sport and Exercise*, 2(2), pp.145-153.

Thomas, D. T., Erdman, K. A., & Burke, L. M. (2016). American College of Sports Medicine Joint Position Statement. Nutrition and Athletic Performance. *Medicine and science in sports and exercise*, 48(3), 543–568. https://doi.org/10.1249/MSS.0000000000000852

Torres-McGehee, T. M., Pritchett, K. L., Zippel, D., Minton, D. M., Cellamare, A., & Sibilia, M. (2012). Sports nutrition knowledge among collegiate athletes, coaches, athletic trainers, and strength and conditioning specialists. *Journal of athletic training*, 47(2), 205–211. https://doi.org/10.4085/1062-6050-47.2.205

Tucker, M., Hargreaves, J., Clarke, J., Dale, D. and Blackwell, G., 2013. The Effect of Caffeine on Maximal Oxygen Uptake and Vertical Jump Performance in Male Basketball Players. *Journal of Strength and Conditioning Research*, 27(2), pp.382-387.

Vitale, K. and Getzin, A., 2019. Nutrition and Supplement Update for the Endurance Athlete: Review and Recommendations. *Nutrients*, 11(6), p.1289.

Wiens, K., Erdman, K. A., Stadnyk, M., & Parnell, J. A. (2014). Dietary supplement usage, motivation, and education in young, Canadian athletes. *International journal of sport nutrition and exercise metabolism,* 24(6), 613–622. https://doi.org/10.1123/ijsnem.2013-0087

Womack, C., Saunders, M., Bechtel, M., Bolton, D., Martin, M., Luden, N., Dunham, W. and Hancock, M., 2012. The influence of a CYP1A2 polymorphism on the ergogenic effects of caffeine. *Journal of the International Society of Sports Nutrition*, 9(1).

ANNEX 1:

Brief overview of original (pre-Covid-19) study plan

The effect of caffeine on intermittent running, jump and reactive agility performance in Basketball athletes

Introduction

Basketball requires numerous complex sport-specific skills, for example jumping (rebounds, blocks), shooting, dribbling and sprinting (Klusemann et al. 2012) and these actions mostly depends on anaerobic pathways (Hoffman et al. 1996). Elite young basketball players spend 15–16% of the total time of a match engaged in high-intensity actions (Abdelkrim et al. 2007) while the remaining time is spent in low-intensity activities, such as sitting and jogging, during which recovery takes place (Drinkwater et al). The aim of this study is to determine the effects of caffeine on basketball athletes' performance (intermittent running endurance, muscle explosive force, and reactive agility).

Caffeine and performance

According to the most recent research, caffeine could delay exhaustion during endurance exercise. In addition, speed and power output may be enhanced in shorter activities（Kavouras, 2004; Davis, 2012; Spriet, 2014).

Caffeine and basketball

Puente (2017) confirmed that because jumping performance is a key variable in basketball activities, the enhancement of jumping ability after the ingestion of caffeine may enhance the overall performance of basketball. As a result, the pre-exercise ingestion of 3 mg of caffeine/kg body mass in the form of an energy drink significantly improved jump performance but it did not have any influence on the precision of the basketball shots. The endurance aspect of basketball, coupled with its high-intensity explosive action, shows that this sport could benefit from these ergogenic effects of caffeine. Rebound in basketball. Basketball players often need to jump vertically when they are tired. Caffeine intake reduces the decline in jumping performance with fatigue (Tucker,2013).

The purpose of this study is to investigate the effect of caffeine on basketball athletes' performance in a series of field-based, sports-specific performance tests. These effects will be examined in a 'fresh' state (i.e. after a day of relative rest) and also on a separate occasion the day after a match in order to determine whether the effects of caffeine differ in a fresh vs "non-fresh" (1 day post-match) state.

Experimental design

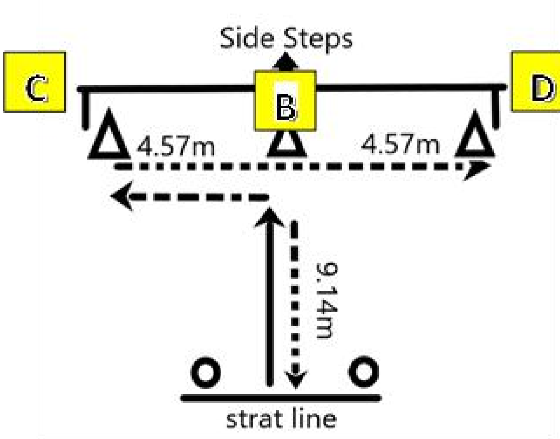
Participants will be required to visit the testing site (University Sports hall) on 5 separate occasions as detailed below.

Preliminary visit (familiarisation)

Participants would be first required to undertake 5 minutes of light exercise as a warm-up (e.g. jogging and stretching). This will be a "free-choice" warm-up and they will be instructed do what they would normally do to prepare for a match or training. This will be noted down so they can be asked to repeat this before subsequent testing visits.

Test 1- maximal jump height: Participants will perform a vertical jump height test using a jump mat. They will perform 3 jumps with 1-2 min rest between each jump.

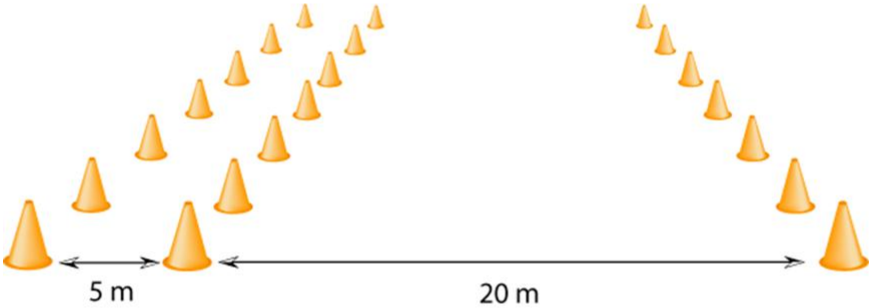
Test 2- reactive agility test: Participants will be required to perform a 'choice' (unplanned) agility run using a timing gates with light stimuli. They run as fast as possible from the start position (at which point a timer will begin) and pass



between 2 'timing gates' at position B. At this point the light on EITHER C or D gates illuminates (at random), indicating which way they must run. The aim is to complete the run in the shortest/fastest time possible. They will have 2 minutes rest and repeat this test two more times (for a total of 3 tests).

Test 3- Yo-Yo intermittent running test:

This test requires intermittent exercise consisting of repeated 20 m shuttle runs (20 m out and 20 m back to the start = 40 m per out and back shuttle). After each 40 m participants have a 5 s rest of jogging around a marker placed 2.5 m behind the starting/finishing line. The pace of each shuttle is dictated by an audible tone played through a loud speaker. The speed is increased regularly until participants are unable to continue with the required pace.



Test 4- maximal jump height: exactly 5 minutes after completing the Yo-Yo test participants will be required to perform the jump test again (exact same procedures as test 1).

Four experimental visits (2nd to 5th visits)

The following week (after the familiarisation visit) participants will be required to return to the sports hall on two separate occasions (within the same week: **visits 2 and 3**) to repeat the testing. One day will be after a day of relative rest (i.e. rest day with no match or strenuous training: "**fresh condition**") and one day will be the day after a match: "**non-fresh condition**". During these visits, participants will undertake the same procedures as described above for the preliminary visit but will consume a gelatine capsule containing either caffeine or the same amount of placebo (microcrystalline cellulose, which is an inert non-digestible substance) approximately 60 minutes before starting the first test. Participants will then repeat this procedure on a separate week (**visits 4 and 5**). They will have placebo on one of the fresh and one of the non-fresh conditions and caffeine on the others. This will be carried out in a randomized, double-blind manner. After completing both participants will be asked to guess what they think you were given in each trial (to check blinding/whether they could tell which was which). The amount of caffeine will 5 mg/kg body mass. After consuming the capsule they will be required to perform the same warm-up that they did before the familiarisation visit above. They will then need to stay in the hall for observation for 45 minutes before beginning the series of tests (same procedures as the familiarisation trial mentioned above). During this time they can perform some light basketball activities (e.g. shooting practice).

They will be asked to provide a saliva sample (by passive dribbling into a small plastic container) before exercise in the familiarisation visit. This will be used to extract DNA and measure CYP1A2 but not ADORA2A genotypes to see whether this influences the way you respond to caffeine. Samples will be extracted immediately (within hours or days), purified DNA stored and all other material disposed of. This, therefore, complies with the HTA requirements.

BRUMS, DOMS, and fatigue questionnaires will be completed at the beginning of each test session to establish if there are any differences in the "fresh" and "non-fresh" conditions.

Statistical analysis

The following software programs will be used: SPSS v 25.0 program (IBM Inc., USA) to perform the statistical calculations using descriptive and inferential statistical tests and to calculate means, standard deviations and ranges. Initially, parametric assumptions will be tested. After that, Student's t test for dependent samples will be used to test for differences in the variables normally distributed between the caffeine trial and the placebo trial (overall/single comparisons). For the non-parametric variables, differences between caffeine trial and the placebo trial will be determined with the Wilcoxon signed-rank test. Yo Yo test of muscle endurance and Jump height and leg muscle power output during the 3 times jump test with fatigue and without fatigue will be compared using a two-way ANOVA (fatigue × without fatigue) with repeated measures for all outcome variables with repeated measures.

ANNEX 2: Sport Supplements knowledge and use questionnaire

This survey is completely anonymous and serves only for academic purpose to evaluate the level of athletes' knowledge on sports supplements

Name:

1. What is your age?

2. Are you: Male ☐ Female ☐ prefer not to say ☐

☐ prefer to self-describe as__________________ (please specify)

3. What is you height (please specify cm, m, feet, etc)?

4. What is your current body weight (please specify kg, pounds, stone, etc)?

5. In which county do you currently live?

6. What is your highest level of competition/performance in basketball?

Recreational ☐ School/University Team ☐ Local Team ☐

Regional Team ☐ National Team ☐

<u>7. A. How long have you been taking part in basketball?</u>

1 year or less ☐ 1-3 years ☐ 3-5 years ☐

over 5 years ☐

7. B. Please provide brief details of your current weekly levels of physical activity (sport, physical fitness or conditioning activities), using the following classification for exertion level:

L = light (slightly breathless)

M = moderate (breathless)

V = vigorous (very breathless)

	Activity	Duration (mins.)	Level (L/M/V)
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			
Sunday			

8. Do you currently take sports supplements?

Yes ☐ (If Yes, please go to question 10)

No ☐ (If No, please go to question 9)

9. If you don't use supplements, what is/are the reason(s)? (Please check all that apply)

I do not need them ☐

They are unhealthy ☐

They are too expensive ☐

My sport does not allow them (i.e. they are banned) ☐

I don't know enough about them ☐

I am concerned about a positive drugs test ☐

Taking supplements is like cheating ☐

Now, please go to question 14

10. If yes, what is the main reason for using sports supplements?

Improve my health ☐ Prevent injury ☐

Recovery ☐

Physical appearance ☐ Performance ☐

11. Where do you usually buy your sports supplements?

Retail store or pharmacy ☐ Athletic trainer or physician ☐ Online store ☐

Nutritionist or dietician ☐ Other ☐

12. Which sports supplements do you use? (name them)

13. How do you decide how much of a supplement to take? (Please only check 1 box)

I calculate it based on my body weight ☐

I am told/ given it by the sports nutritionist/ dietitian ☐

I follow the instructions on the label/ manufacturers website ☐

Unsure ☐

N/A – I don’t use supplements ☐

14. How do you decide whether a supplement is safe to use? (Please check all that apply)

It’s says on the label ☐

I ask a sports nutritionist/ dietitian/ medical professional ☐

I ask my coach/ teammates ☐

I check the manufacturer’s website ☐

I do my own research using the internet, books, journals etc ☐

No supplement is safe ☐

N/A (I don't use supplements) ☐

15. Do you think there is a health risk associated with taking sports

supplements?

Yes, all supplements carry a health risk ☐

Some supplements have health risks ☐

No, no supplements carry a health risk ☐

ANNEX 2 DATE CORRELATION

Table 11 **Cross Table: Endurance**

Count

		AGE		Total
		19-22	23-27	
Endurance	Strongly positive	1	1	2
	Positive	8	12	20
	No effect	9	6	15
	Negative	4	1	5
	Unsure	6	4	10
Total		28	24	52

Chi-square Test

	Value	Degree of freedom	Asymptotic significance (two-way)
Pearson Chi-fang	21.354[a]	4	.000
Likelihood ratio (L)	23.960	4	.000
Linear correlation	5.305	1	.021
Number of valid cases	52		

Table 12 **Cross Table: Speed**

Count

		AGE		Total
		19-22	23-27	
Speed	Strongly positive	0	1	1
	Positive	10	8	18
	No effect	10	9	19
	Negative	1	0	1
	Unsure	7	6	13
Total		28	24	52

Chi-square Test

	Value	Degree of freedom	Asymptotic significance (two-way)
Pearson Chi-fang	4.567[a]	4	.335
Likelihood ratio (L)	5.365	4	.252
Linear correlation	.618	1	.432
Number of valid cases	52		

Table 13 **Cross Table: Power**

Count

		AGE		Total
		19-22	23-27	
Power	Strongly positive	0	1	1
	Positive	9	9	18
	No effect	9	10	19
	Negative	2	0	2

	Unsure	7	4	11
Total		27	24	51

Chi-square Test

	Value	Degree of freedom	Asymptotic significance (two-way)
Pearson Chi-fang	10.765[a]	4	.029
Likelihood ratio (L)	11.548	4	.021
Linear correlation	3.930	1	.047
Number of valid cases	51		

Table 14 **Cross Table: Strength**

Count

		AGE		Total
		19-22	23-27	
Strength	Strongly Positive	2	2	4
	Positive	6	8	14
	No effect	9	6	15
	Negative	1	0	1
	Unsure	9	8	17
Total		27	24	51

Chi-square Test

	Value	Degree of freedom	Asymptotic significance (two-way)
Pearson Chi-fang	8.137[a]	4	.087
Likelihood ratio (L)	10.486	4	.033
Linear correlation	.243	1	.622
Number of valid cases	51		

Table 15 **Cross Table: Concentration**

Count

		AGE		Total
		19-22	23-27	
Concentration	Strongly positive	5	4	9
	Positive	9	15	24
	No effect	4	2	6
	Negative	4	0	4
	Strongly Negative	2	0	2
	Unsure	4	3	7
Total		28	24	52

Chi-square Test

	Value	Degree of freedom	Asymptotic significance (two-way)
Pearson Chi-fang	19.566[a]	5	.002
Likelihood ratio (L)	24.706	5	.000
Linear correlation	9.139	1	.003
Number of valid cases	52		

Table 16 **Cross Table: Reactions**

Count

		AGE		Total
		19-22	23-27	
Reactions	Strongly Positive	5	5	10
	Positive	15	9	24
	No effect	3	2	5
	Negative	1	0	1
	Unsure	4	8	12
Total		28	24	52

Chi-square Test

	Value	Degree of freedom	Asymptotic significance (two-way)

Pearson Chi-fang	7.954[a]	4	.093
Likelihood ratio (L)	8.685	4	.069
Linear correlation	5.795	1	.016
Number of valid cases	52		

Table 17 **Cross Table: calmness**

Count

		AGE		Total
		19-22	23-27	
Calmness	Strongly Positive	1	4	5
	Positive	2	7	9
	No effect	5	3	8
	Negative	7	3	10
	Strongly Negative	7	0	7
	Unsure	6	7	13
Total		28	24	52

Chi-square Test

	Value	Degree of freedom	Asymptotic significance (two-way)
Pearson Chi-fang	17.228[a]	5	.004
Likelihood ratio (L)	21.177	5	.001
Linear	4.741	1	.029

correlation			
Number of valid cases	52		

Table 18 **Cross Table: Fat loss**

Count

		AGE		Total
		19-22	23-27	
Fat loss	Strongly Positive	0	1	1
	Positive	4	10	14
	No effect	11	8	19
	Negative	3	0	3
	Strongly Negative	2	1	3
	Unsure	8	4	12
Total		28	24	52

Chi-square Test

	Value	Degree of freedom	Asymptotic significance (two-way)
Pearson Chi-fang	5.737[a]	5	.333
Likelihood ratio (L)	6.246	5	.283
Linear correlation	2.979	1	.084
Number of valid cases	52		

Question 3 Correlation between training history and caffeine intake.

Table 19 **Cross Table: Use and training history**

Count

		How long have you been taking part in basketball?			Total
		Over 5 years	3-5 years	1-3 years	
Do you currently use caffeine? In the caffeine use questions earlier, did you indicate that you were a current or previous caffeine user?	Yes	12	4	0	16
	No	18	7	1	26
	Currently	8	2	0	10
Total		38	13	1	52

Chi-square Test

	Value	Degree of Freedom	Asymptotic significance (two-way)
Pearson Chi-fang	1.265[a]	4	.867
Likelihood ratio (L)	1.656	4	.799
Linear correlation	.012	1	.915
Number of valid cases	52		

Table 20

Cross Table			
Count			
	11. Do you currently use caffeine at all? This includes for sport or exercise OR for other reasons not related to sport or exercise		Total
	No	Yes	

3.e. In which country do you currently live?	China	73%	27%	30
	UK	80%	20%	20
Total		76%	24%	50

Chi-Square Test

	Value	df	Progressive Sig. (Both sides)
Pearson Chi-square	11.970a	7	.102
Likelihood ratio	12.910	7	.074
N in valid cases	50		

Table 21 **Cross Table**

Count

		Level			Total
		Uni Team	Regional Team	National Team	
Endurance	Strongly Positive	1	0	1	2
	Positive	8	0	12	20
	No Effect	8	5	2	15
	Negative	4	0	1	5
	Strongly Negative	4	1	5	10
Total		25	6	21	52

Chi-square Test

	Value	Degree of Freedom	Asymptotic significance (two-way)
Pearson Chi-fang	35.698[a]	12	.000
Likelihood ratio (L)	29.403	12	.003
Linear correlation	.210	1	.647
Number of valid cases	52		

Table 22 **Cross Table**

Count

		Level			Total
		Uni Team	Regional Team	National Team	
Speed	Strongly Positive	0	0	1	1
	Positive	8	1	9	18
	No Effect	11	4	4	19
	Negative	1	0	0	1
	Strongly Negative	5	1	7	13
Total		25	6	21	52

Chi-square Test

	Value	Degree of Freedom	Asymptotic significance (two-way)
Pearson Chi-fang	9.857[a]	12	.629
Likelihood ratio (L)	11.631	12	.476
Linear correlation	.340	1	.560
Number of valid cases	52		

Table 23 **Cross Table**

Count

		Level			Total
		Uni Team	Regional Team	National Team	
Power	Strongly Positive	0	0	1	1
	Positive	10	0	8	18
	No Effect	8	4	7	19
	Negative	1	1	0	2
	Strongly Negative	5	1	5	11
Total		24	6	21	51

Chi-square Test

	Value	Degree of Freedom	Asymptotic significance (two-way)
	10.513[a]	12	.571
Pearson Chi-fang	13.397	12	.341
Likelihood ratio (L)	.070	1	.791
Linear correlation	51		

Table 24 **Cross Table**

Count

		Level			Total
		Uni Team	Regional Team	National Team	
Strength	Strongly Positive	2	0	2	4
	Positive	6	0	8	14

	No Effect	8	4	3	15
	Negative	0	1	0	1
	Strongly Negative	8	1	8	17
Total		24	6	21	51

Chi-square Test

	Value	Degree of Freedom	Asymptotic significance (two-way)
Pearson Chi-fang	20.712[a]	12	.055
Likelihood ratio (L)	20.022	12	.067
Linear correlation	.052	1	.819
Pearson Chi-fang	51		

Table 25 **Cross Table**

Count

		Level			Total
		Uni Team	Regional Team	National Team	
Concentration	Strongly Positive	5	0	4	9
	Positive	11	3	10	24
	No Effect	2	1	3	6
	Negative	3	1	0	4
	Strongly Negative	1	0	1	2
	Unsure	3	1	3	7
Total		25	6	21	52

Chi-square Test

	Value	Degrees of Freedom	Asymptotic significance (two-way)
Pearson Chi-fang	8.388[a]	15	.907
Likelihood ratio (L)	11.318	15	.730
Linear correlation	.000	1	1.000
Pearson Chi-fang	52		

Table 26 **Cross Table**

Count

		Level			Total
		Uni Team	Regional Team	National Team	
Reactions	Strongly Positive	5	0	5	10
	Positive	16	2	6	24
	No Effect	0	2	3	5
	Negative	0	1	0	1
	Strongly Negative	4	1	7	12
Total		25	6	21	52

Chi-square Test

	Value	Degree of Freedom	Asymptotic significance (two-way)
Pearson Chi-fang	23.359[a]	12	.025
Likelihood ratio (L)	22.363	12	.034
Linear correlation	2.988	1	.084
Pearson Chi-fang	52		

Table 27 **Cross Table**

Count

		Level			Total
		Uni Team	Regional Team	National Team	
Calmness	Strongly Positive	3	0	2	5
	Positive	2	1	6	9
	No Effect	2	2	4	8
	Negative	7	1	2	10
	Strongly Negative	6	1	0	7
	Unsure	5	1	7	13
Total		25	6	21	52

Chi-square Test

	Value	Degree of Freedom	Asymptotic significance (two-way)
Pearson Chi-fang	18.214[a]	15	.252
Likelihood ratio (L)	21.628	15	.118
Linear correlation	.522	1	.470
Pearson Chi-fang	52		

Table 28 **Cross Table**

Count

		Level			Total
		Uni Team	Regional Team	National Team	
Fat loss	Strongly Positive	1	0	0	1
	Positive	5	1	8	14
	No Effect	8	4	7	19
	Negative	3	0	0	3
	Strongly Negative	2	0	1	3
	Unsure	6	1	5	12
Total		25	6	21	52

Chi-square Test

	Value	Degree of Freedom	Asymptotic significance (two-way)
Pearson Chi-fang	15.008[a]	15	.451
Likelihood ratio (L)	17.520	15	.289
Linear correlation	.221	1	.638
Pearson Chi-fang	52		

Caffeine questions

16. Do you currently use caffeine?

Yes ☐ …… if yes, for how long have you been you been using it? ____________

No ☐ ……..if no, have you ever used it in the past? ____ if yes, how long is it since you stopped using it? ______

17. Attitudes Concerning Caffeine's Performance-Influencing Effects.

Please rate the impact that you believe caffeine to have on various aspects of performance. (Please note, there is no right or wrong answers, this is entirely about your opinion/what you think. Please answer honestly based on what you think).

Area of performance	**Strongly negative**	**Negative**	**No effect**	**Positive**	**Strongly positive**	**Unsure**
Endurance						
Speed						
Power						
Strength						
Concentration						

Reactions (reaction time)						
Calmness						
Fat loss						

Please rate each item as either containing no caffeine, low or high amounts of caffeine.

(Please note, this is entirely about your opinion/what you think. If you do not know what a product is, please do not give a rating for amount and instead select the box for "unfamiliar with item").

	Unfamiliar with item	**Contains no caffeine**	**Contains small amount of caffeine (i.e. less than 50 mg)**	**Contains large amo caffeine (i.e. more than 50 mg)**
Coke, 1 can				
Diet Coke, 1 can				
Isotonic sports drink (e.g. Gatorade, Powerade, Lucozade Sport), 500 mL				
Sprite, 1 can				
Red Bull, 1 can				
Red Bull sugar-free, 1 can				

Protein shake, 450ml				
Black tea, 1 cup				
Iced tea, 16 oz/500 mL				
ProPlus, 2 tablets				
Instant coffee, 1 tsp powder				
Ground coffee, 1 scoop brewed				
Iced coffee, 600mL				
Orange juice, 16 500 mL				
Monster, 1 can, 500 ml				
Water, 500 ml				
Milk chocolate, 40 g bar				
Dark chocolate, 40 g bar				

19. Sources of Information on Caffeine and Exercise.

Please indicate which of the following sources of information you use to inform your decisions and practices on using caffeine for sport/exercise (Please note, there is no right or wrong answers, this is entirely about where you get your information from, you can choose one more answer).

Please mark ALL that apply

Never considered	
Self-experimentation	
Fellow athletes	
Magazines	
Journal article	
Internet	
Friend	
Food/Drug ads	
Doctor	
Dietitian	
Pharmacist	
Coach	
Trainer	
Manager	
Parent	

Relative	
Health food store attendant	
TV/Radio ad	
Other (please give details)	

<u>20. Suggested Dose of Caffeine to Influence Performance</u>

If you wanted to consume caffeine to enhance your performance, how much would you need to take to achieve this?

21. <u>Frequency and Severity of Side Effects</u>.

	Barely noticeable	**Noticeable but minor**	**Noticeable Moderate**	**Noticeable Severe**	**Very severe**	**Unsure**
Tremors/ shakes						
Headaches						
Elevated heart rate						
Increased sweating						
Increased urine volume or frequency						
Abdominal or gut discomfort						
Caffeine addition						
Other (please give details)						

If you do use caffeine for exercise, have you ever experienced any side-effects (e.g. tremors/ shakes, headaches, elevated heart rate, increased sweating, increased urine volume, abdominal/gut discomfort, and caffeine addiction)? If yes, please indicate the typical severity of these side effects in the table below

22. For any of the side-effects you have experienced (mentioned above), please indicate the frequency with which these happen to you (wen using caffeine during exercise).

	Never (0%)	**Sometimes** (less than 25% of times).	**25-50 %** of times	**51-75 %** of times	**75-99 %** of times	**Always (100%)** every time	Unsure
Tremors/ shakes							
Headaches							
Elevated heart rate							
Increased sweating							
Increased urine volume or frequency							

Abdominal or gut discomfort							
Caffeine addition							
Other (please give details)							

Additional questions for caffeine users

Please complete the following to indicate how much you consume in a typical day.

Please indicate how many of the following you would normally have (normal day).

Daily Caffeine Consumption Questionnaire

Coffee (140 ml serving)	Morning (6am – 12pm)	Afternoon (12pm – 6pm)	vening (6pm – 2am)	Night (2am – 6am)
Regular brewed Percolated Drip-brewed Espresso shot Regular instant Decaffeinated Brewed Instant		______________	______________	______________
Ready to drink Coffee (140ml serving) Starbucks doubleshot coffee Starbucks doubleshot light Starbucks doubleshot				

energy Starbucks Frappuccino caramel Starbucks Frappuccino mocho Starbucks Frappuccino coffee Other _____________				
Tea (140 ml serving) Tea-brewed Decaffeinated tea-brewed Tea-instant Other____________				
Cocoa (140ml				

serving)				
Chocolate (230g serving)				
Soft drinks (330ml serving) Coca-Cola Diet Coca-Cola Zero Coca-Cola Coca-Cola Life Cherry Coke Diet Cherry Coke Vanilla Coke Vanilla Coke diet Dr. Pepper Diet Dr. Pepper Chery Dr. Pepper Diet Cherry Dr. Pepper Mountain Dew Diet Mountain Dew Pepsi Cola				

Diet Pepsi Pepsi Max Pepsi Wild Cherry Diet Pepsi Wild Cherry Other_______________				
Energy drinks (330ml serving) Red bull Monster Rockstar No Fear Amp energy Full throttle Irn-Bru Relentless Other_______________				
Over the counter drugs (1 tablet)				

NoDoz Excedrin extra strength Excedrin menstrual complete Dexatrim Midol Anacin Other_______________				
Energy shots (60ml serving) Red bull NOS powershot Stok coffee shop Other_______________				
Food (flavoured with chocolate) Chocolate pudding (120g)				

Chocolate cereal (1 cup) Chocolate (30ml) Chocolate chip cookies (55g) Chocolate ice-cream (340g) Chocolate chip waffles (2 waffles) Chocolate hazel nut spread (2 table spoon) Other_______________				