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Article Title: Breathing Pattern Disorder: Therapeutics

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Key Points

- Athletes with breathing pattern disorder usually experience hyperventilation and symptoms such as dyspnea, tight chest, tachycardia, and/or lightheadedness.
- The approach for correcting a breathing pattern disorder must be multifactorial and consider the following aspects: technical, physical, psychological, and social domains of every athlete.
- The best targeted breath retraining consists of smooth coordination and cooperation between the respiratory muscles and initial movement of the lower ribcage.
- There is not a one-size fits all approach to breathing pattern retraining. Rather a toolbox approach may be the most successful means of treating breathing pattern disorder.

Synopsis

Breathing pattern disorder (BPD) is an abnormal pattern of ventilation and movements of the upper and lower ribcage, and abdomen that results in a constellation of symptoms. This paper discusses the management of BPD from a technical standpoint. Since there is not a one-size-fits-all model for practice, we offer a toolbox approach to care with quick reference tables and diagrams that allow the practitioner to easily find treatment approaches that may suite their athlete. While this article uses the athlete as a reference for treatment, there is also a consideration for how to approach the co-morbid patient as well.

Key/Essential Headings

Introduction

Breathing pattern disorder (BPD), also known as dysfunctional breathing pattern or dysfunctional breathlessness, is an abnormal pattern of ventilation and movements of the upper and lower ribcage and abdomen that results in a constellation of symptoms. In most instances of BPD, therein lies a greater sympathetic activation of the nervous system via the vagus nerve as compared to parasympathetic activation (Migliaccio et al, 2023). When the sympathetic nervous system is heightened, this reinforces states of fight and flight and keeps the athlete, who already tends towards states of hypervigilance, hyperventilation, and upper ribcage breathing, in a dysfunctional state, which may be conscious or unconscious. Their inability to regulate their nervous system, and thereby control their breathing, can lead the athlete to feel dyspnea, lightheaded, dizzy, or in some cases tachycardic (Vidotto et al, 2019).

There is no consensus on a gold standard for diagnosis, in part due to limited availability to complete objective measures of breathing patterns. Diagnostic suggestions are presented in Chapter 12. There is agreement that breathing pattern retraining is helpful in correcting breathing pattern abnormalities (Grillo et al, 2023). This paper will serve as a resource for insight into how to approach the management of BPD from a technical standpoint.

The technical approach for treating BPD has not widely been described, and this is especially so in patients with co-morbidities. The following will mainly describe breath pattern retraining techniques for the athlete, who represents a patient without co-morbid disease concerns. The gaps of care for co-morbid populations will also be addressed.

Discussion

Management of BPD

Usually, the pathogenesis of a disorder will prove beneficial when considering treatment options. However, the pathophysiology of BPD is not widely understood. Current

research seems to suggest that the mechanisms for BPD to occur are multifactorial and could be due one or more of the issues highlighted in Figure 1.

Regardless of the possible mechanism, the approach for correcting BPD should be a multifactorial and consider the following aspects: technical, physical, psychological, and social domains of every athlete (Figure 2).

After acknowledging the significant areas of impact, breathing pattern retraining can begin by laying a foundation that considers technical retraining from the upper airway through to how to activate lower ribcage movement, in the context of other aspects impacting progress and performance, such as physical, psychological, or social.

Breath retraining should start with a focus on optimizing breathing pattern mechanics at rest. This way, the athlete can focus on techniques for optimal breathing patterns without the stress of movement. There are a number of methods that can be adopted to encourage an athlete to optimize their breathing pattern, which are summarized in Table 2.

Parasympathetic activation

Beginning to retrain the resting breath can help to activate the parasympathetic system and allow for better breath control in and out of sport (Migliaccio et al, 2023). Once proper at rest breathing techniques can be repeated, a progression to movement within sport can be initiated. The learned techniques for breath retraining should start with the nose and continue to the diaphragm.

There are numerous ways to activate the parasympathetic nervous system. Light exercise, meditation, yoga, and diaphragmatic breathing are several options (Gerritsen et al, 2018). When thinking about improving exercise overtime, it is best to choose a means of activating the parasympathetic nervous system that can also translate easily into exertion. For these reasons, we shall focus on techniques that enhance diaphragmatic engagement and facilitate ribcage movement.

Nasal breathing

Nasal breathing has been widely studied and has been known to activate the parasympathetic nervous system by decreasing blood pressure, perceived exertion, and hyperventilation (Watso et al, 2023 and Recinto et al, 2017). Furthermore, nose breathing optimizes ventilation by regulating ventilatory drive and oxygen uptake, encourages rhythm, filters, warms, and humidifies air. The benefits continue from the localized nasal passages themselves by preventing bronchoconstriction, and allows for the increase of nitric oxide, which helps with vasodilation, improved pulmonary hemodynamics, and alveolar uptake (Courtney et al, 2022). There is no evidence to suggest that vocal cord dysfunction or exercise induced laryngeal obstruction can be triggered at rest when nasal breathing. While there are numerous benefits to nasal breathing, we acknowledge that this technique for breathing optimization is not ideal for everyone. Many suffer from chronic sinusitis and congestion, or the inability to facilitate

proper air flow due to physical constraints, for example, a deviated septum. This can make the idea of breathing solely through the nose more anxiety provoking than relaxing. Another drawback to nasal breathing alone is that this type of breathing is not sustainable in high intensity athletics. In most cases, the benefits of nasal breathing far outweigh the drawbacks, and therefore make it an easy entry point for calming the nervous system and starting breath retraining at rest.

Optimizing breathing pattern mechanics

An often more difficult transition than nasal breathing is optimizing the upper torso movement from upper ribcage breathing to lower ribcage breathing. It is tempting to allow upper ribcage breathers to continue as such. However, this pattern of breathing fosters more dysfunction, reduces ribcage movement, and limits tidal volume. Upper ribcage breathers are more prone towards slightly larger inspiratory flow rates as compared to expiratory flows, which can lead to breath stacking and hyperinflation, especially if there also concurrently exists airflow obstruction. Thereby, promoting hyper ventilatory states and dyspnea. When breathing primarily with the upper chest, the diaphragm is also put in a suboptimal position to encourage lung expansion and maintain intrathoracic pressures (Harbour et al, 2022).

The key element of optimizing breathing pattern mechanics is to ask the athlete to engage in exercises that encourage lateral movement of the lower ribcage round the 11th and 12th rib at the initiation of the inspiratory phase of breathing (Smyth et al, 2022). Focusing on lower ribcage breathing will promote initiating breathing with the diaphragm and allowing complete movement of the ribcage (Figure 3).

In Figure 3, take notice to the high intensity exercise model and how the ribcage should move laterally, forwards, backwards and with a little uplift towards reaching total lung capacity (Smyth et al, 2022). Aids such as hands or stretchy bands placed on the 11th and 12th rib can help as cues for the athlete to focus the initial movement. When exhaling, the breath should focus on smooth, relaxed, and unforced recoil of the ribcage. With increased activity, the exhalation becomes more active, which increases the passive elastic forces of the ribcage, lowers diaphragmatic work, and stabilizes posture (Harbour et al, 2022).

While this pattern of breathing may take time to learn, as it requires cooperation between the respiratory muscles and ribcage, the payoff is worth it. Techniques including slow breathing with extending the exhale in comparison to the inhale, and using biofeedback sensor-related interventions, allow for real time breath-by-breath capturing (Smyth et al, 2021). Such biofeedback related interventions include capnography or plethysmography, and manual manipulation to encourage efficient breathing. The athlete will likely have to learn how to also execute the above movement pattern whilst exercising, which may also require them to learn how to use this optimized breathing pattern when breathing through their mouth. A list of benefits and drawbacks when establishing optimal breathing mechanics can be found in Table 1.

Optimizing breathing pattern for exercise

When considering the athlete, it is very important to understand the ventilatory, postural, technical, and tactical demands of their sport. However, despite these, the fundamental breathing pattern movements encouraged during rested breathing should also be encouraged during exercise (Smyth et al, 2022). That is, the inspiratory phase of breathing should be initiated from the lower ribcage and the exhalation phase should rely on recoil. The practitioner should also consider some athletes may need to inhale through their mouth or even breath hold to provide buoyancy during exercise, such as when swimming, while other athletes may compromise their breathing by rounding their spine forward, such as when bike riding. As these examples reflect, a one-size-fits-all model may not be optimal for everyone. That said, there are tools that can be resourced when approaching treatment for BPD related to exercise (Table 2). These tools can be individualized to accommodate the athlete's specific needs or limitations.

Treatment Approach for Co-morbid populations - Taking what we know and applying it to patient care

While a routine approach to treatment would be easy to replicate and standardize across populations, there exists the inherent variability between individuals and disease state that also needs to be considered when teaching breathing retraining. In general, BPD occurs concurrently with hyperventilation and poor breathing mechanics. Therefore, the focus of breath retraining should begin with the goal of reducing states of hyperventilation by increasing the volume of exhaled air and facilitating proper biomechanics of breathing. A universally achievable idea. However, if there is a co-morbidity, such as diaphragm paralysis is present (Whyte et al. 2006), or if one partner in the communication of the lower ribcage is not able to participate, there would be a need to pivot towards alternative ways of encouraging a longer exhalation or coordinating the ribcage, diaphragm, and other accessory muscles of inspiration and expiration.

Initiating research with athletes is a fantastic opportunity to observe BPD and be able to observe the benefits of breath retraining without other confounding comorbidities. However, there are numerous other populations of patients, especially those with chronic lung disease, who also exhibit BPD, and would benefit from breath retraining (Santino et al, 2020). The treatment approach laid out above for athletes serves as a nice foundation for teaching patients with other comorbidities how to retrain their breathing as well. Of course, it will be important to keep in mind each patient population and their unique variations to consider, such as working with advanced pulmonary hypertension patients and their need for supplemental oxygen therapy. In these co-morbid populations, there would also be a high consideration for assessing respiratory muscle function, and starting inspiratory muscle training is warranted.

Future of BPD Management

There is a limited supply of high-quality research outputs to objectively support most management strategies for BPD. The heterogeneity of BPD adds a layer of complexity

to delivering randomized clinical control trials. However, this should not stop researchers from attempting to deliver them. Future research should look to utilize the above methods into randomized clinical control trials to improve our understanding of their effectiveness in BPD management.

Methods such as 3D motion capture can provide a high-quality objective analysis of breathing patterns (Smyth et al, 2021 & 2022). This technique is a useful research tool, but given its high cost, low accessibility, and need for highly skilled bio mechanist analysis means it is not a practical tool to use in a clinic setting. Future management of BPD would be significantly enhanced by developing accessible tools that can objectively assess breathing pattern. These could then be used to provide objective data to form parts of the diagnosis of BPD and serve as feedback systems to support management of BPD (Smyth et al, 2021).

Lastly, improved education for medical practitioners and athletic coaches will allow for a better understanding of the condition and a more effective means of support for athletes and patients with BPD. This can be achieved by developing more online tools to educate and teach the basics of optimized breathing patterns at rest and during exercise. There also needs to be a more efficient way of signposting this disease state and training to practitioners who specialize in BPD management.

Clinic Care Points

- No gold standard for diagnosis
- Limited research that objectively investigates management of BPD
- Encourage initiation of breath with lateral movement of lower ribcage
- Reduce states of hyperventilation - Focus on elongating the volume of exhale
- Optimize breathing pattern at rest to lay a foundation for optimized breathing during activity
- Consider the sport or disease state in the ongoing management of BPD
- Encourage proper breathing mechanics: nose, ribcage, diaphragm, accessory respiratory muscles working in conjunction

Summary

The mechanisms for BPD development are multi-factorial and are likely to differ between individuals. Once BPD is suspected in an athlete the management should consider the individual and why they may have developed BPD. This should include considering the technical aspects of breathing pattern, wider physical limitations of the individual, psychological, and social aspects. BPD management should initially focus on optimizing breathing pattern, even if the athlete reports symptom development during exercise. Once breathing patterns are optimized at rest, the athlete can begin to engage in exercise to support optimizing breathing patterns during exercise. BPD management strategies used with athletes can be adapted for use in patients who also have BPD. Future research should focus on establishing a mechanism of the condition and developing a stronger evidence base for current BPD therapies. In addition, the development of accessible and accurate devices to objectively measure breathing

pattern will enhance diagnosis and management of BPD. Finally, BPD education for medical practitioners, coaches, and athletic trainers will enhance understanding, detection, and management of BPD in athletic populations.

Disclosures

- Cori Fratelli, MSN, FNP-C reports the following financial relationships with Boehringer Ingelheim Pharmaceuticals: Advisory board, Consultant, Speaker
- John Dickinson, PhD has nothing to disclose

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Figures and Tables (Submitted in separate documents upload)

Figure 1: Possible mechanisms for BPD development

Figure 2: Four areas for consideration to support changes in breathing patterns

Figure 3: Breathing patterns at rest and during high intensity exercise in healthy athletes. Adapted from Smyth, C.M.E., Winter, S.L., & Dickinson, J.W. (2022). Breathing pattern disorders distinguished from healthy breathing patterns using optoelectric plethysmography. *Translational Sports Medicine. Dec 22*; 22. Article ID 2816781 | https://doi.org/10.1155/2022/2816781

Table 1: Benefits and Drawbacks when Establishing Optimized Breathing Mechanics

Table 2: Breathing Pattern Disorder Manage Approach for the Athlete