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Chronic Exertional Symptoms Post-Concussion in the Military Population: The Role of Heart Rate Variability and Graded Exercise Treatment

Introduction

Since 2001, over 325,000 SM's have sustained a traumatic brain injury with over 80% of those being mTBI[1], making it a prominent issue in military healthcare. While most sports concussions usually resolve with rest and gradual return to activity, up to 35% of military-related concussions result in chronic physical, sensory, emotional, and affective symptoms that make it unsafe for them to perform full active duty responsibilities[2]. While the Zurich sports concussion guidelines prescribe cognitive and physical rest until all symptoms resolve[3], specific parameters for type and duration of rest have not been established, and the majority of current evidence actually demonstrates negative physiologic and cognitive effects of rest beyond a few days after mTBI[4]. Thus, research has begun to investigate the effectiveness, safety, optimal parameters, and reasoning for gradual exercise progression following concussion.

Heart Rate Variability Post-Concussion

Autonomic nervous system (ANS) dysfunction has repeatedly been theorized to be associated with chronic mTBI symptoms since many of the processes the ANS is responsible for regulating remain impaired in patients with chronic mTBI[3,5]. The ANS functions to continuously regulate heart rate in response to blood pressure oscillations, respiration rate, thermoregulation, and circadian rhythm[6]. These autonomic modulations result in slight differences in time periods between consecutive heart beats, termed heart rate variability (HRV).[7] Reduced HRV indicates impaired efficiency of autonomic modulation, and analysis of HRV has been shown in multiple studies to be a feasible, reliable and accurate measure of ANS functioning[7]. Reduced HRV and impaired cerebral autoregulation has also been demonstrated in patients during the post-acute/chronic stages of mTBI[8,9,10]. Thus, HRV may be a viable target for intervention to improve symptoms of chronic concussion, but research in this area is only in the very initial stages.

Interestingly, several studies of athletes in the acute stage of concussion show that HRV differs significantly between those with mTBI and matched controls only during response to exercise, and not at rest[11,12]. Similarly, a recent cross-sectional study of university level athletes in the chronic stage of concussion exhibited significantly reduced HRV in comparison to matched controls during exertion but not at rest[13]. The reduced HRV after concussion may play into the body's inability to properly auto-regulate constant cerebral perfusion pressure and cerebral blood flow in response to the increased systemic arterial pressure that occurs with exertion[14], explaining this phenomenon and why symptoms of concussion, such as headache and dizziness, tend to be aggravated with exertional activity. This evidence further indicates the possibility of the continued influence of ANS dysfunction on chronic concussion symptoms with exertional activity.

Research regarding HRV in specifically the military population following mTBI is lacking, but early pilot studies indicate that pain, post-traumatic stress symptoms, and mTBI may together reduce HRV in SM's. Importantly, this evidence also indicates that HRV in this population may be modified by intervention that increases respiratory activity, such as aerobic exercise[15,16]. Thus, overall evidence points to a convincing role of ANS dysfunction in continuance of chronic concussion symptoms that affect exertional abilities, but further research targeting populations in the chronic stages of concussion and military populations is warranted. Additionally, analysis of HRV via a polar or seems to be a relatively easy, inexpensive, and quick technique to reliably and accurately assess ANS functioning in this population, and has good potential to be utilized to monitor patient progress and help guide return to duty decisions.

Graded Exercise Treatment

Considering the need for athletes, SM's and other individuals post-concussion to return to regular activity without symptom limitation, and that rest beyond the first few days after concussion may have more negative than beneficial effects[4], establishment of an effective and safe exercise rehabilitation program for those with chronic concussion symptoms and exertional complaints has become a focus in the most leading-edge research. Additionally, exercise has been shown to increase the respiratory activity that may be necessary to increase HRV and improve cerebral blood flow[17], further justifying its potential benefits of exercise training. Thus far, initial stages of research have shown a significant association between chronic exertional symptoms and abnormal cerebral blood flow on fMRI[18], as well as suggested that damaged communication between autonomic brain centers and baroreceptors of the heart may play a role in the impaired autoregulation and HRV that leads to persistent exertional symptoms[19].

The Zurich Consensus Statement provides non-specific recommendations for athletes to begin with light activity and progress to sport specific activity once symptomfree at rest[3]. However, these recommendations are very broad and non-specific, and there is no recommendation or consensus on safe effective treatment if symptoms do not resolve. Leddy and Willer have established what seems to be the most specific protocol for a gradually progressive sub-symptom threshold exercise treatment for this population[20], which has demonstrated decreased exertional chronic concussion symptoms in athletes in several initial studies[18,20]. This protocol utilizes the Buffalo Concussion Treadmill Test (BCTT) to provide a baseline and assess patient progress. The individual walks on a treadmill at gradually increasing incline until concussion symptoms are aggravated. The individual then begins exercising at 80% of that heart rate for 20 minutes multiple times a week and is re-evaluated every 2 weeks with the BCTT to set a new heart rate goal for exercise until the patient can complete the full 20 minute BCTT without symptom exacerbation.[20]

On average, current studies of submaximal exercise treatments have demonstrated decreased number and severity of exertional symptoms, increased exercise tolerance, and improved ability to return to prior level of activity in athletes and community populations in comparison to continued rest[4]. It is important to note that combination of graded submaximal training may be more beneficial when incorporated into a comprehensive therapy plan[4]. Also, only initial stages of research have been completed to address exercise treatment for chronic post-concussion symptoms. Thus, the existing evidence is of relatively low quality, lacking randomization, large sample sizes, and specific comparison to other forms of treatment. Thus, further higher level research with larger sample sizes and randomization is necessary.

Generally, it has been accepted that these clinical effects of graded aerobic exercise training in athletic populations may be generalized to military patients due to similarly vigorous activity requirements. However, no studies in the military population have been performed to confirm this postulation. Considering the high incidence of military mTBI[1], the differing mechanism of injury in military-related concussions, and the tendency of military-related concussions to result in more chronic symptoms than sports-related[2], research specific to this population is also warranted. At this point, the state of evidence on this subject consistently suggests that controlled progressive aerobic exercise training at a sub-symptom level based on heart rate reached during treadmill testing may be both safe and effective in decreasing chronic exertional concussion symptom severity and decreasing activity limitations due to symptom exacerbation with exertion. However, due to the small quantity of relevant research, best clinical judgement and patient preferences should also be taken into account to make the most informed treatment decisions.

References

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