**Sub-Maximal Exercise and Rest Recommendations for Service Members Following mTBI**

**Introduction**

More than 280,000 service members have sustained a Traumatic Brain Injury (TBI) between the year 2000 and the second quarter of 2013. Eighty-three percent of the TBIs sustained in 2013 are classified as mild. Mild TBI (mTBI) is characterized by memory loss lasting less than 24 hours, loss of consciousness lasting less than 30 minutes, and a MRI or CT with normal results. 1 Rest is commonly recommended when a condition is misunderstood, as is the case with the largely subjective diagnosis of mTBI. Limited evidence supports rest “until asymptomatic” as an appropriate treatment option for mTBI. 2 Current Veterans Affairs/Department of Defense guidelines include a graded return to normal activity as soon as possible following mTBI. 3 This exemplifies the shifting view from complete bed rest towards activity limitation after mTBI. 2,3

Most individuals diagnosed with mTBI recover between 10 days and 1 month following injury; however, approximately 3-5% continue to have persistent physical, cognitive, and/or emotional symptoms and are diagnosed with Post-Concussion Syndrome (PCS). 4-6 The treatment of persistent post-concussive symptoms in service members is an ongoing issue, given that blast injuries are the most common form of mTBI sustained in theater. 7 Several authors have suggested that the mechanism behind a blast injury may increase the likelihood of both persistent post-concussive symptoms and Post Traumatic Stress Disorder (PTSD). 8,9

Healthcare providers often find that service members with blast mTBI experience persistent post-concussive exertional symptoms. These patients largely recover within the acceptable timeframe, but continue to report vertigo, diplopia, nausea, and other debilitating symptoms during physical activity. The guidelines that exist for persistent post-concussive symptoms are merely expert opinion, and disagreed on by many clinicians. 10-12 Research suggests that sub-maximal exercise is more beneficial to an individual than rest following mTBI. 4,5,13,14 This sub-symptom level may be determined by a graded exercise evaluation to determine the heart rate or duration at which symptom onset occurs. 4,5 A specific evidence-based intervention has not been described to assist individuals in return to asymptomatic activity if they cannot do so independently. 4 In service members with mTBI, does sub-symptom exercise lead to a quicker alleviation of

persistent post-concussive exertional symptoms than rest?

**Summary of the Evidence**

*Research Design*

Limited evidence exists on the topic of exercise versus rest as treatment for persistent post-concussive symptoms. The intervention studies are case series, and the remaining literature tends to consist of retrospective and prospective cohorts. These designs are almost always appropriate because of the limited evidence to support or refute the topic at hand. They are not the preferred level of evidence but are necessary to provide enough information to warrant randomized control trials in the future.

The current research has small but clearly described populations. The mean age of subjects ranges from approximately 14 to 40 years, with the majority of subjects in their mid-twenties and male. The time of testing and/or intervention varies between studies. Some employ baseline measurements immediately post-mTBI while others wait for several months. 6,11,13,15 This range mirrors the acute timeframe that subjects should improve, so is therefore appropriate for assessing subjects with persistent post-concussive symptoms. Most results in the literature are reported as statistically significant.

Some of the current emphasis on mTBI assessment and treatment is focused on the military; however, other research has varied populations in terms of age, occupation, and injury circumstances. Many of these populations have components that are applicable to service members. The majority of subjects in the current literature are male and mid-twenties, similar to the typical United States service member. Many of the younger subjects in the current research are high school or college student-athletes. 11,13 The physical demands for these individuals are higher than a typical sedentary individual, thus making the research more relatable to the military lifestyle. The majority of literature includes subjects who meet the accepted mTBI diagnosis guidelines, but several studies have exclusion criteria that make them less pertinent to service members. Some studies exclude subjects with comorbidities. 4,15 Majerske et al chose to exclude individuals who were taking any form of mediation at the time of injury or at any evaluation, 13 yet polytrauma and medication use is almost always the case with military mTBI. Blast survivors typically have multisystem involvement including orthopedic trauma, limb loss, visual deficits, burns, and PTSD. 6,9,16 Overall, the current literature approach to mTBI is appropriate considering the limited available evidence. Components of each population studied may be applied to the service member population in this circumstance.

*Sub-Maximal Exercise Intervention*

The current literature on exercise, rest, and mTBI may be grossly classified by intervention or self-report. The three experimental studies discussed in this paper submitted each subject to an incremental treadmill exercise test, which was stopped for symptom exacerbation. 4,5,14 Two studies evaluated the efficacy of a graded, sub-maximal, individualized aerobic exercise program, although only one describes the specific intervention. 4,5 Leddy et al instructed subjects to perform aerobic exercise 5-6 days per week at 80% of the maximum heart rate achieved during each subject’s treadmill test. 4 Gagnon et al developed a program for children with post-concussive symptoms lasting longer than four weeks. This program involved individualized graded rehabilitation that included aerobic exercise, sport-specific coordination visualization exercises, and a home program. 14 The majority of interventions were implemented well within one year of mTBI, and continued until each subject presented symptom-free during graded exercise. 4,5,14

The studies that examined sub-maximal exercise as treatment for persistent mTBI symptoms showed positive results. The adult subjects were able to aerobically exercise to their age-predicted maximum heart rate without exacerbation of symptoms. 4,5 All subjects were able to return to full daily functioning following the exercise program. 14 Results of these studies also indicate that graded exercise leads to significant and rapid symptom improvement. 4,14 Only one study specified the mean duration of time, 4.4 weeks, required to achieve these results. 14 Leddy et al determined that athletes experienced faster recovery than non-athletes. 4 In a systematic review, Schneider et al reported a general decrease in symptoms and increase in function following graded exercise after mTBI. The authors also conclude that additional research is required secondary to a lack of randomization that makes causal association difficult. 17

*Self-Report and Outcome Measures*

A fair amount of overlap is present for post-concussion outcome measures utilized in the current literature. Most, with the exception of a measure described by Lange et al, are validated and reliable. Lange et al created the Clinical Tracking Form Telephone Follow-Up Interview specifically for their study to examine variables frequently associated with mTBI including health, alcohol use, and life satisfaction. Symptoms such as headaches, dizziness, memory, attention, balance, and depression were also addressed. 6 The Graded Symptom Checklist and other post-concussive symptom scales are frequently used. 4,11,13,15 Neuropsychological test batteries were administered in several studies. 11,13 Additional outcome measures used in the literature include those related to illness perception, depression, balance, and motor skills. 11,14,15 Many of these were implemented during telephone follow-ups with subjects. 5,6,15

Self-reports are frequently utilized in the current mTBI literature. Lange et al used the aforementioned measure to examine PCS symptom reporting trends in service members during the five years following mTBI. 6 McCrea et al conducted one of the sole studies to examine rest immediately following mTBI. They examined the effects of a symptom-free waiting period (SFWP) by administering the Graded Symptom Checklist, a neuropsychological test battery, and several balance and concussion outcome measures several times in the acute period following mTBI. 11 Majerske et al compared subjects’ self-reported physical and cognitive activity levels to post-concussion cognitive and symptom outcome measures. 13

The literature concerning risk factors for PCS and reporting of PCS symptoms within the military concluded that 20-50% of subjects met criteria for PCS following mTBI. 6,15 All-or-nothing behavior, when the individual cycles between periods of complete activity and complete rest, and negative head injury perceptions were determined to be significant predictors of PCS. 15 No significant difference was shown between those with and without PCS for gender, age, education, occupation, marital status, GCS score, and amnesia, but more than 25% of PCS subjects were diagnosed with PTSD. 6,15Most subjects reported symptoms of PCS at 36 and 60 months, and 15-30% reported new PCS symptoms at follow-up despite being asymptomatic at baseline. 6

Results from the current literature are fairly broad but homogenous. The evidence indicates that 80% of repeat concussions occur within the first 10 days of initial injury; however, athletes are no more or less likely to suffer from a repeat injury when they observe a SFWP. 11Athletes with the highest self-reported levels of physical and cognitive activities following mTBI may have the worst visual memory and reaction times. Conversely, athletes with self-reported intermediate activity levels may have better outcomes than both those who report low or high activity levels. 13

Schneider et al concluded that there is minimal evidence to support rest following concussion. Overall, there is an absence of evidence-based recommendations for any treatment, so the best approach may be a graded return to cognitive and physical activities. 17

**Discussion and Conclusions**

*Critical Points*

Treatment recommendations for persistent post-concussive symptoms are often broad and do not suggest specific evidence-based interventions. The current literature lacks upper tier evidence to demonstrate whether increased or reduced activity levels are detrimental or helpful to an individual recovering from mTBI. A SFWP prior to return to sport may be unnecessary, but there does appear to be a window of time (7-10 days) during which repeat injury is most likely. This period of time is not mutually exclusive with the timeframe of persistent post-concussive symptoms. Cognitive and physical rest is therefore indicated in the acute period, but should become activity limitation in the weeks and months that follow. Activity in excess may have a relationship with slower reaction time and decreased neurocognitive scores, and no activity may encourage similar results. The current evidence suggests that graded exercise testing with respect for symptom exacerbation is safe for individuals with PCS. Sub-maximal, graded aerobic exercise is shown to be a safe and potentially effective intervention from individuals with PCS. An initial period of rest followed by sub-maximal exercise may be beneficial to individuals with persistent post-concussive symptoms. Significant variability exists in symptom reporting habits as well as changes in symptoms that occur over time, so follow-up after any mTBI is indicated. Current evidence on this topic is sparse, and high-level research is necessary to evaluate when rest may be appropriate and guidelines for exercise.

*Limitations and Bias*

The available evidence on mTBI and treatment recommendations is limited and lacks high quality randomized control trials (RCT). The literature discussed in this paper was never randomized and rarely regulated. Causation is difficult to prove in many studies due to the lack of control groups and use of multifaceted interventions. It is impossible to demonstrate that symptom recovery was not spontaneous without a control group. Results should be interpreted with caution due to small sample sizes and limited follow-up present in most of the literature. Some authors leave a great deal to interpretation and guesswork by the reader by failing to describe specific guidelines and interventions. 4,11 The interventions that are described are frequently unsupported by prior research. The research that is supported was often conducted by the same authors or in the same location as earlier studies. 4,5

The subjective nature of mTBI contributes to some limitation as well. An accurate mTBI diagnosis may be difficult to obtain in subjects who have sustained polytrauma. 6 The large presence of self-report measures has been discussed; the subjective nature of mTBI symptoms combined with telephone follow-ups lend themselves to difficulty with replicating methods and interpreting results. 5,6,15 Schneider et al summarizes the available evidence for interventions in systematic review that is limited to only sport-related concussion. This is quite restricting in terms of the already short supply of evidence on the topic of mTBI. 17

*Service Members and Exertional Symptoms*

The current literature is not sufficient to answer the above question regarding service members and persistant post-concussive exertional symptoms. The majority of research does not specifically mention exertional symptoms and the published evidence is not always directly relatable to service members. Some of this research may be adapted to the military population and lifestyle. The best available evidence may be combined to form the general guidelines that are utilized in some military settings today. Service members who have suffered mTBI are frequently instructed to rest for approximately a month, and then gradually return to pre-injury activity. Physical therapists may utilize graded exercise testing and interventions to rehabilitate those with persistent symptoms. Additional research is necessary to assess predictive factors for persistent symptoms following mTBI, in order to facilitate prevention strategies. Ideally, an RCT will be conducted in which subjects with exertional symptoms are compared to healthy controls. The subjects should be assessed with a graded treadmill protocol, and then submitted to either rest or an individualized, sub-maximal aerobic program.

*Application to Clinical Practice*

Many patients recover from mTBI independently, but the available evidence shows how physical therapists can help improve the quality of life for those who suffer from persistent symptoms. Physical therapists have the knowledge and skill to safely administer an exercise assessment and implement a structured exercise program. Physical therapists are also the ideal healthcare providers to frequently follow-up with mTBI patients. These patients have the potential to remain symptomatically the same or decline, and physical therapists can ensure that the patients receive the appropriate medical care. The evidence supports the need for an established graded intervention protocol that involves physical activity. A specific intervention program in which a patient is active but not overly so is essential. Service members must be educated on the possible detrimental effects that over-activity can have on recovery following mTBI.

The “all-or-nothing” principal is extremely applicable to service members in this situation. Many service members dislike being injured and inactive, and often attach a stigma to injury. Physical therapists should educate all patients with a recent history of mTBI about symptoms that are likely related to concussion, so symptoms are not confused with other factors such as PTSD or medication use. Healthcare providers should err on the side of caution by educating all mTBI patients, given the variability in reporting habits and symptom exacerbation over time. Physical therapists may be able to help prevent the onset of PCS by mitigating negative perceptions of mTBI and ensuring that patients do not over or under-exert themselves.

Most importantly, healthcare providers should approach a patient with persistent post-concussive symptoms as a team. Factors that affect service members such as type of mTBI (blast, blunt, or combination), PTSD, depression medication use, and high physical work demands have not been addressed concomitantly in the literature and must be dealt with on a case-by-case basis. This research will be combined with the current Defense and Veterans Brain Injury Center guidelines and applied to a Capstone project as a learning module for healthcare providers. The module will aim to educate physical therapists and other healthcare providers on exercise and rest recommendations for service members with persistent post-concussive symptoms. Experience coupled with the best available evidence must be employed in treating service members following mTBI until further research is available.

**References**

 1. DoD worldwide numbers for TBI. [http://www.dvbic.org/dod-worldwide-numbers-tbi](http://www.dvbic.org/dod-worldwide-numbers-tbi%22%20%5Ct%20%22_blank). Accessed 11/13/2013, 2013.

2. Silverberg ND, Iverson GL. Is rest after concussion "the best medicine?": Recommendations for activity resumption following concussion in athletes, civilians, and military service members. *J Head Trauma Rehabil*. 2013;28(4):250-259.

3. VA/DoD clinical practice guideline for management of concussion/mild traumatic brain injury. [http://www.healthquality.va.gov/mtbi/concussion\_mtbi\_full\_1\_0.pdf](http://www.healthquality.va.gov/mtbi/concussion_mtbi_full_1_0.pdf%22%20%5Ct%20%22_blank). Published April 2009. Accessed 11/12/2013, 2013.

4. Leddy JJ, Kozlowski K, Donnelly JP, Pendergast DR, Epstein LH, Willer B. A preliminary study of subsymptom threshold exercise training for refractory post-concussion syndrome. *Clin J Sport Med*. 2010;20(1):21-27.

5. Baker JG, Freitas MS, Leddy JJ, Kozlowski KF, Willer BS. Return to full functioning after graded exercise assessment and progressive exercise treatment of postconcussion syndrome. *Rehabil Res Pract*. 2012;2012:705309.

6. Lange RT, Brickell TA, Ivins B, Vanderploeg RD, French LM. Variable, not always persistent, postconcussion symptoms after mild TBI in U.S. military service members: A five-year cross-sectional outcome study. *J Neurotrauma*. 2013;30(11):958-969.

7. Sports concussion vs. military concussion | DVBIC. [http://www.dvbic.org/sports-concussion-vs-military-concussion](http://www.dvbic.org/sports-concussion-vs-military-concussion%22%20%5Ct%20%22_blank). Accessed 9/5/2013, 2013.

8. Sevagan G, Zhu F, Jiang B, Yang KH. Numerical simulations of the occupant head response in an infantry vehicle under blunt impact and blast loading conditions. *Proc Inst Mech Eng H*. 2013;227(7):778-787.

9. Kontos AP, Kotwal RS, Elbin RJ, et al. Residual effects of combat-related mild traumatic brain injury. *J Neurotrauma*. 2013;30(8):680-686.

10. Guskiewicz KM, McCrea M, Marshall SW, et al. Cumulative effects associated with recurrent concussion in collegiate football players: The NCAA concussion study. *JAMA*. 2003;290(19):2549-2555.

11. McCrea M, Guskiewicz K, Randolph C, et al. Effects of a symptom-free waiting period on clinical outcome and risk of reinjury after sport-related concussion. *Neurosurgery*. 2009;65(5):876-82; discussion 882-3.

12. Ferrara MS, McCrea M, Peterson CL, Guskiewicz KM. A survey of practice patterns in concussion assessment and management. *J Athl Train*. 2001;36(2):145-149.

13. Majerske CW, Mihalik JP, Ren D, et al. Concussion in sports: Postconcussive activity levels, symptoms, and neurocognitive performance. *J Athl Train*. 2008;43(3):265-274.

14. Gagnon I, Galli C, Friedman D, Grilli L, Iverson GL. Active rehabilitation for children who are slow to recover following sport-related concussion. *Brain Inj*. 2009;23(12):956-964.

15. Hou R, Moss-Morris R, Peveler R, Mogg K, Bradley BP, Belli A. When a minor head injury results in enduring symptoms: A prospective investigation of risk factors for postconcussional syndrome after mild traumatic brain injury. *J Neurol Neurosurg Psychiatry*. 2012;83(2):217-223.

16. Scherer MR, Schubert MC. Traumatic brain injury and vestibular pathology as a comorbidity after blast exposure. *Phys Ther*. 2009;89(9):980-992.

17. Schneider KJ, Iverson GL, Emery CA, McCrory P, Herring SA, Meeuwisse WH. The effects of rest and treatment following sport-related concussion: A systematic review of the literature. *Br J Sports Med*. 2013;47(5):304-307.