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Does Active Recovery Provide Faster Reduction in Symptoms and a Faster Return to Play for Colege Athletes Compared to Conservative Rest After a Concussion?

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DOES ACTIVE RECOVERY PROVIDE FASTER REDUCTION IN SYMPTOMS AND A FASTER RETURN TO PLAY FOR COLEGE ATHLETES COMPARED TO CONSERVATIVE REST AFTER A CONCUSSION?

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Abstract

Purpose: Sports-related concussions are one of the most hotly debated topics in sports medicine today. Research surrounding concussion has experienced significant growth especially in the areas of incidence, assessment, and recovery. Previously athletes were told to rest after suffering a concussion. Athletes were told to limit physical and cognitive activities; they were instructed to avoid anything that may increase or reaggravate their symptoms. Current research is now recommending active recovery programs and stating that just resting detrimental for athletes after suffering a concussion and can prolong recovery time. Guided aerobic exercise is currently the best recommended form of active recovery. The purpose of this study is to investigate if active recovery provides a faster reduction in symptoms for and a faster return to play for college athletes compared to conservative rest after suffering a concussion.

Methods: Using a cross-sectional analysis, this study analyzed active concussion treatments and measured those results against similar studies using conservative treatment.

Results: Active recovery was associated with earlier clearance for return to sport. Active recovery athletes were cleared for return to sport in fewer days.

Conclusion: This study begins to answer the question regarding the future of concussion management and its transition from conservative treatment to active recovery. Future studies are needed to examine the optimal timing and dose of guided aerobic exercise for the active treatment of concussions. as well as, its potential to prevent persistent post-concussive symptoms.

Chapter I

Statement of Purpose

Despite a significant increase in research dedicated to identifying and managing sport-related concussion, it remains one of the most complex injuries sports medicine professionals face (Broglio et al., 2014). The purpose of this study is to investigate if active recovery provides a faster reduction in symptoms and a faster return to play for college athletes compared to conservative rest after suffering a concussion. Active recovery includes guided aerobic exercise, having the athlete use a stationary bike or treadmill to increase their heart rate.

The Need for Critical Review

Concussions are often described as a hidden epidemic because they are not readily recognized by the injured players, their coaches, or parents (Delaney et al., 2014). This may be due to a lack of medical knowledge about concussions among youth, parents, and coaches, who therefore can fail to recognize and report concussions (Eagles et al., 2016). The lack of knowledge makes it difficult for athletic trainers to know the best methods to use when one of their athletes suffers a sport-related concussion. In 1997, the American Academy of Neurology published one-size-fits-all guidelines on concussion management, in which the athlete would simply rest until symptom-free. The initial period of rest can range widely, with some athletes being withheld from exercise for weeks or months depending on the duration of their symptoms (Neurology, 1997). Several medical organizations, including the American Academy of Neurology, now recommend a more individualized approach to concussion management (American Academy of Neurology, 2010). Recent studies have suggested that normal daily

activities after sport-related concussions are safe and may speed recovery, compared with a strict rest protocol (Grool et al., 2016).

Significance to Athletic Training.

As licensed medical professionals, athletic trainers receive comprehensive didactic and clinical training in concussion management. Athletic trainers are typically the first providers to identify and evaluate concussed athletes and are integral in the concussion management and return-to-play decision-making process (Broglio et al., 2014). Concussion management has both medical and legal implications. Previous lawsuits against athletic trainers and team physicians have addressed the premature clearing of athletes and withholding athletes from play for too long after suffering a concussion out of fear of letting the athlete return prematurely. (Plevretes v La Salle University, 2007). Recurrent concussions to several high-profile athletes, some of whom were forced into retirement, as a result, have increased awareness among athletic trainers by showing the severity of the effects a concussion to have and a push to reevaluate how we look at concussion protocols. Bridging the gap between research and clinical practice is the key to helping athletic trainers manage athletes who suffer a sport-related concussion (Guskiewicz et al., 2004).

Chapter II: Methods

This chapter addresses the methods used to identify and appraise current literature to determine the best current treatments of concussions in collegiate athletes. Multiple research databases and search terms were used, which generated 207 research articles. The articles were assessed for their significance to the review and the final 19 articles were selected when inclusion and exclusion criteria were met.

Research Strategies

The purpose of this literature review was to answer the practice question: does active recovery provide a faster reduction in symptoms and a faster return to play for college athletes compared to conservative rest after suffering a concussion? Several databases were utilized to develop a representative sample of clinical trials and systematic reviews in the treatment of concussion. Searches were conducted in Academic Search Premier, ERIC, PubMed, CINAHL, and NATA. The specific search terms used were: “Concussion”, “Traumatic Brain Injury”, “Rehabilitation”, “Collegiate”, “Hockey”, “Active Recovery”, “Return to Play”, and “Leddy”. The researcher also specifically searched for Leddy because Dr. John Leddy is involved in some of the most recent research in concussion and how to treat concussions actively using treadmills and stationary bikes. His center is the first in the United States to use a standardized treadmill test to establish recovery from concussion and to use exercise in the rehabilitation of patients with prolonged concussion symptoms.

Inclusion and Exclusion Criteria

The studies selected for this literature review addressed concussion treatments in their effectiveness and comparison to simple rest. Included research articles utilized treatments such

as balance testing, stationary bikes and treadmills, aerobic exercise, medications, cognitive rehabilitation, physical rest, cognitive rest, vestibular and oculomotor rehabilitation, and Impact testing. These nine specific interventions were used as inclusion due to being the most up to date methods of treating concussions. To ensure the use of the most up to date information, all articles needed to be published within the last 16 years. Only two studies were included that were published over 10 years ago. One was included to compare the original NATA updated position statement from 2004 to an updated position statement in 2014. The other included article was the earliest work to begin testing active concussion rehabilitation techniques against rest by Leddy et al. (2007). Articles included in this review consisted of studies done in the United States, Canada, and England. Exclusion criteria eliminated studies that had fewer than 10 subjects and that were not systematic reviews. Studies older than 16 years were also excluded from the literature review. Lastly, studies were excluded if they were not available in full text.

Studies Selected

The initial data search yielded 207 studies. After utilizing the inclusion and exclusion criteria, 19 research articles were selected to be included in the review. All studies published between 2004-2019 with 13 systematic reviews, four cohort studies, one randomized controlled trial, and one case study. All research took place in the United States, Canada, and England.

Evaluation Criteria

This capstone project analyzed 19 articles. Reviewed articles were put into an evidence synthesis matrix (Appendix A). For this matrix, articles were broken down into seven different categories: the purpose, participant sample, design, measurements, the results/conclusions, recommendations, the level of evidence, and the quality of the article.

The systematic review articles were evaluated using the Critical Appraisal Skills Program (CASP) for systematic reviews. The CASP uses three broad issues that need to be considered when appraising a systematic review study. Are the results of the study valid? What are the results? Will the results help locally? The full Critical Appraisal Skills Program consists of 10 questions that are designed to help think about the issues systematically. The first two questions are screening questions and can be answered quickly. If the answer to both is yes, it is worth proceeding with the remaining questions. There is some degree of overlap between the questions; you are asked to record a yes, no, or can't tell most of the questions. A few italicized prompts are given after each question. These are designed to remind why the question is important.

The cohort, case study, and randomized clinical trial articles were also evaluated using the Critical Appraisal Skills Program (CASP). Their checklists were similar to the systematic review checklist but included an extra question about the recruiting of the participants.

The CASP checklists were designed to be used as educational pedagogic tools, as part of a workshop setting, therefore it does not suggest a scoring system. However, this matrix uses a unique scoring system developed for this project. There are 10 questions for the systematic review checklist and eight of them were asked to answer yes, no, or can't tell. For these questions, each one was assigned a +1 for yes answers, 0 for no answers, and +0.5 for can't tell answers. Total scores ranging from 6-8 were determined to be high quality, scores of 4-6 were determined to be moderate quality and article with a final score 3.5 or below received a grade of low quality. Each article was also assigned a level of evidence to each article using the hierarchy of evidence for intervention studies from the evidence-based practice in nursing and healthcare: a guide to best practice.

Summary

Databases were searched utilizing the online library system at Bethel University, Gustavus Adolphus College, and google to compile articles that addressed concussion treatments and rehabilitation techniques. Inclusion and exclusion criteria were added to the search to narrow the results to 19 of the most significant articles for the review. The articles were then evaluated and appraised for quality using the Critical Appraisal Skills Programme.

Chapter III

Synthesis of Major Findings

The National Athletic Trainers' Association created its initial position statement regarding the management of sport-related concussions in 2004. This research was encouraged because NATA made research-based recommendations for football between 1976 and 1980 that resulted in a significant reduction in the incidence of fatalities and nonfatal catastrophic injuries. "Research about different care approaches to sport-related concussions have provided athletic training and medical professions with valuable new knowledge in recent years" (Guskiewicz et al., 2004). The decrease of fatalities and nonfatal catastrophic injuries was due to rule changes outlawing spearing and butt blocking, player education about rule changes, the implementation of equipment standards, alternative assessment techniques, heightened awareness on the dangers of athletes returning to sport too soon, and an increase in athletes' awareness of the risks associated with concussion. The NATA position statement of 2004 recommended putting an athlete through a SAC, BESS, neuropsychological test battery, and symptom checklist. The NATA recommends an athlete be symptom-free for seven days before returning to participation immediate, rest is recommended during the early stages, but complete bed rest is not recommended. Guskiewicz et al. (2004) state the athlete should resume normal activities of daily living as tolerated while avoiding activities that potentially increase symptoms. Once an athlete is symptom-free, the athlete should begin a graded program of physical and mental exertion. Guskiewicz et al. (2004) suggest that a seven-day waiting period can minimize the risk of recurrent injury. This systematic review (position statement) is of high quality based upon the CASP scale. This study had 7/8 answers as "Yes" or "Can't Tell" indicating that this article is of high quality. The weaknesses of this study include a lack of a clearly focused question.

The National Athletic Trainers' Association (2014) provided an updated position statement about how athletic trainers should manage athletes who suffer a sport-related concussion. The NATA wanted to provide athletic trainers, physicians, and other healthcare professionals with best-practice guidelines for the management of sport-related concussions. The NATA position statement (2014) defined a concussion as a "trauma-induced alteration in mental status that may or may not involve loss of consciousness". This position statement wants health care providers to focus on the cessation of symptoms, restoration of motor control, and neurocognitive test results, in which all of these are reverted to pre-injury levels before a return to play progression is implemented. The National Athletic Training Association recommended doing so by instructing the athlete to avoid any physical activity and to limit cognitive activity. Broglio et al. (2014) stated physical activity during the acute phase can have a detrimental effect on recovery, but the effect of cognitive stress on concussion recovery is less clear. Once a patient no longer reports concussion-related symptoms and is cleared by a clinical examination, then the next step is to take an objective assessment and have it compared to the athlete's baseline performance.

Once an athlete is no longer reporting concussion-like symptoms, has a normal clinical exam, they are now ready to progress to the second stage in the return to play progression. The first stage involved no activity and focused on allowing time for the athlete to rest and become symptom-free. The second stage instructs the athlete to perform some light exercise and requires the athlete to keep their heart rate below 70 percent of their age-predicted maximal heart rate. The third stage allows for the athlete to participate in sport-specific activities without the threat of contact from teammates or others. The fourth stage allows for the athlete to return to practice on a non-contact basis and includes resistance training. The fifth stage allows for the athlete to be

a full participant in practice with no limitations. The sixth and final stage is a full return to play for the athlete. If symptoms return at any point during these stages, the athlete is instructed to stop and return to the previous stage. This position statement does recommend physical and cognitive rest during the acute recovery period (NATA, 2004). Majerske et al. (2008) also stated that activities of daily living that do not exacerbate symptoms may be beneficial to the patient's recovery and should be allowed. Majerske et al. (2008) also recommend that moderate levels of supervised exertion during recovery were associated with better visual memory and reaction time outcomes and may be beneficial to recovery. This systematic review (position statement) is of high quality based upon the CASP scale. This study had 7/8 answers as "Yes" or "Can't Tell" indicating that this article is of high quality. Weaknesses of this study include lack of a clearly focused question and offered as more of a summary of the current research and knowledge known in the field of concussion management.

Broglio et. al. (2015) stated that concussion is one of the most hotly debated topics in sports medicine today, but they also felt that there is limited research on the most effective rehabilitation approaches. They decided to do a systematic review to evaluate the current literature for and against physical and cognitive rest and the emerging targeting vestibular, oculomotor, and pharmacological interventions for the rehabilitation of sport-related concussion. The International Concussion in Sport Group (2013) recommends the cornerstone of concussion management is physical and cognitive rest until the acute symptoms resolve and then a graded program of exertion prior to medical clearance. This recommendation has been interpreted by many clinicians to mean that all concussed athletes should be restricted from all physical and cognitive activity until symptoms resolve (Broglio et al., 2015). This shutdown approach

following a concussion has potential pitfalls for patients including hyperawareness of symptoms, somatization, social isolation, and other potential co-morbid concerns.

The premise that rest is the most effective management strategy for all concussed patients assumes that all concussions are alike. Recovery is known to be influenced by several modifying factors, such as sex (Covassin et al., 2006), concussion history (Iverson et al., 2004), and age (Field et al., 2003). A single human study evaluating exercise shortly after concussion indicated that athletes engaging in a medium level of physical and cognitive activity performed better on the neurocognitive test than those with no physical and cognitive activity and those reporting the highest levels of physical and cognitive activity (Majerske et al., 2008). Even though this is promising in the recommendation of patients engaging in a more active concussion rehabilitation, this should be interpreted cautiously because the physical and cognitive activity was self-reported and it was not known at what point post-injury the athletes elected to begin physical activity.

Researchers (Collins et al., 2014) have suggested that oculomotor and vestibular symptoms and impairment may constitute unique clinical subtypes of sport-related concussion along with cognitive-fatigue, anxiety-mood, cervical and post-traumatic migraine. These subtypes require targeted therapies and treatments in order to be managed most effectively (Collins et al., 2014). Schneider et al. (2014) conducted a randomized controlled trial with a sample of 12-30-year-olds with dizziness, neck pain, and/or headache following a sport-related concussion. After eight weekly physical therapy sessions, consisting of vestibular and cervical spine rehabilitation, subjects in the treatment group were nearly four times more likely to be medically cleared when compared to a control group. Some research suggests that prescribed physical and cognitive rest in the acute stage of concussion may be of benefit to some athletes.

However, other studies have indicated that an early return to light to moderate physical activity may be effective for other athletes following concussion (Broglio et al., 2015) Initial empirical evidence indicates that vestibular or oculomotor interventions may be useful in mitigating these issues and enhancing the recovery of athletes with sport-related concussion. However, additional research regarding which interventions are most effective for each type of impairment and symptom as well as the optimal number and length of therapy sessions needed to obtain the desired effect is warranted. This systematic review is of high quality based upon the CASP scale. This study had 8/8 answers as "Yes" or "Can't Tell" indicating that this article is of high quality. Weaknesses of this study include limited empirical support for the rehabilitation strategies discussed in this paper, necessitating additional research on their effectiveness following a concussion.

Although concussions are a common sports injury (Meehan et al., 2011), there are few published data on effective treatments. Many current recommendations are based on anecdotal evidence and consensus. William Meehan et al. (2011) conducted a non-exhaustive systematic review to highlight some of the more common recommendations and common therapies for sports-related concussions with the most published data available. Current guidelines recommend physical and cognitive rest as the mainstays for treating sport-related concussions (McCrory et al., 2009). Majerske and colleagues (2008) studied the effect of overall activity, combining both physical and cognitive activity, on symptoms and neurocognitive performance during concussion recovery. Majerske et al. (2008) results suggest that high levels of overall activity may interfere with recovery, whereas more moderate levels may be acceptable, or even beneficial. The investigators point out the retrospective nature of this study leaves it vulnerable because of the different injury severities. Those engaging in moderate activity may have started

with a less severe injury than those engaging in minimal activity. Nevertheless, Majerske et al. (2008) findings indicate the need for further investigation into the effects of activity on concussion recovery. Comper et al. (2005) suggest that cognitive rehabilitation is effective for treating the effects of a concussion; however, given the short duration of signs and symptoms, McCory et al. (2009) states the routine use of cognitive rehabilitation in the management of sport-related concussions is unnecessary and most likely not beneficial. The review by Meehan et al. (2011) does not give any recommendations but rather promotes the current information available and raises concerns for conservative and active types of concussion rehabilitation. This systematic review is of moderate quality based upon the CASP scale. This study had 4.5/8 answers as "Yes" or "Can't Tell" indicating that this article is of moderate quality. Weaknesses of this study include a lack of a clearly focused question, not all-important, relevant studies were included, and the authors did not do enough to assess the quality of the included studies. The authors, rather, provided a discussion of some of the more common recommendations and common therapies.

Leddy et al. (2018) reviewed recent observational and experimental data and presented the evidence that subthreshold aerobic exercise normalizes the cerebrovascular physiological dysfunction and is medicine for patients with concussion and persistent post-concussive symptoms. Leddy discusses the systematic evaluation of exercise tolerance after a concussion using the Buffalo Concussion Treadmill test and reviews the utility of the Buffalo Concussion Bike Test, the data from which are used to establish an individualized heart rate of subthreshold exercise to safely speed recovery, which also may work in the acute recovery phase after a sport-related concussion with the potential to reduce the incidence of persistent post-concussive symptoms. Thomas et al. (2015) conducted a randomized controlled study and the results

showed that strict rest beyond two days prolonged symptomatic recovery from a concussion. Leddy also conducted a study using the Buffalo Concussion Treadmill Test, which is a systematic and reliable method to determine the symptom-exacerbation exercise threshold in concussed patients (Leddy et al., 2011). Since the treadmill is not appropriate for all patients, Leddy and his team developed the Buffalo Concussion Bike Test. First, they would calculate the patient's oxygen consumption (VO_2) using the American College of Sports Medicine Metabolic Equations. Next, they determine the bike resistance requirement based on the individuals' weight to achieve an equivalent VO_2 for each stage. The patient would begin on the bike at 60 revolutions per minute while the initial resistance is set. The resistance is increased every two minutes. Through the process, the patient's heart rate, symptom severity, and rated perceived exertion are recorded until voluntary exhaustion or symptom exacerbation. Based off his own Buffalo Concussion Treadmill and Bike Tests and his systematic review of studies for and against exercise testing and/or prescribed aerobic exercise, Leddy et al. (2018) concluded that individualized aerobic exercise is a non-pharmaceutical intervention that challenges the old paradigm of prolonged rest, has minimal adverse effects, can be implemented with standard equipment, and could be used at many physician offices and health facilities. Leddy also states that further research should examine the optimal timing and dose of guided aerobic exercise for the active treatment of concussions, its potential to prevent persistent post-concussive symptoms, and more thoroughly investigate the physiological and neurophysiological mechanisms for its effect. This systematic review is of high quality based upon the CASP scale. This study had 7.5/8 answers as "Yes" or "Can't Tell" indicating that this article is of high quality. Weaknesses of this study include lack of all-important outcomes being considered including optimal timing and dose of guided aerobic exercise for the active treatment of concussion.

Although most patients with a concussion recover within days to weeks, a small but significant minority develop persistent signs and symptoms of post-concussion syndrome (Leddy et al., 2007). The standard treatments of post-concussion syndrome, rest and cognitive adaptation, have limited effectiveness. Prolonged rest, however, leads to deconditioning especially in athletes, and may cause secondary effects including depressive symptoms. Leddy et al. (2007) propose that post-concussion syndrome results from ongoing central and systematic physiological regulatory dysfunction after traumatic brain injury and Leddy further proposed that this physiological dysfunction may be reduced or alleviated by individualized controlled sub-symptom threshold aerobic rehabilitation. From this systematic review, Leddy et al. (2007) recommend that the exercise rehabilitation of post-concussion symptom patients should be an individualized, progressive sub-symptom threshold aerobic exercise program. The controlled exercise-based rehabilitation program for post-concussion symptoms should exacerbate symptoms while the central regulatory and autoregulatory adjust. Past research has tended to neglect physiological variables such as indicators of fitness and regulatory and autoregulatory function. Future research in post-concussion symptoms patients should measure the effects of regular sub-symptom threshold exercise on cerebral autoregulation and the variables that affect it. This systematic review is of high quality based upon the CASP scale. This study had 7/8 answers as “Yes” or “Can’t Tell” indicating that this article is of high quality. The weaknesses of this study include research to see if the benefits are worth the harms and costs of the treatment.

The current recommendation for concussion treatment is to follow graduated protocols for return to play. These protocols have largely been developed through sports-related concussion research and consist of an algorithmic approach to physical and cognitive rest/activity (McCrory et al., 2013). However, there is minimal evidence for their fundamental

principles, such as type or duration of rest and, consequently, they rely heavily on expert opinion. Burke et al. (2014) wanted to assess the characteristics of current clinical trials investigating the treatment of concussions. Burke and his team extracted clinical trial data from Clinicaltrials.gov and seven additional World Health Organization primary registries. These databases were accessed up until 3 October 2013. Burke's study used search terms of "concussion" or "mild traumatic brain injury" and filtered for interventional trials. Trials that were terminated, already published, or not interventional trials of concussion or mild traumatic brain injury were excluded. Of the 142 clinical trials identified, 71 met inclusion criteria. Trials had a median estimated enrollment of 60 participants. There was a wide range of treatments studied including medications, cognitive and behavioral therapies, devices, dietary supplements, return to activity, and rest, among others. One major limitation of Burke's systematic review was the small sample sizes of the studies. Overall, only 19.7% of trials had an estimated sample size of over 100 participants (Califf et al., 2012). It is suggested that more appropriately targeted research efforts with enhanced methodological rigor are required to adequately address the ongoing need for evidence-based treatment of concussions (Burke et al., 2014). This systematic review is of moderate quality based upon the CASP scale. This study had 4.5/8 answers as "Yes" or "Can't Tell" indicating that this article is of moderate quality. Weaknesses of this study included lack of a clearly focused question, lack of all the important, relevant studies being included, and only included U.S. based trials.

The rationale for recommending cognitive and physical rest after a sport-related concussion includes reducing the potential for a repeat concussion while the brain may still be vulnerable from the initial concussion (Giza et al., 2014). Valovich et al. (2017) conducted a systematic review regarding rest and return to activity after sport-related concussion. The

research was collected from the Cochrane Central Register of Controlled Trials and four other databases using terms related to concussion, mild traumatic brain injury, physical and cognitive rest, and return to activity. Studies were included if they were published in English; were original research; and evaluated the use of, compliance with, or effectiveness of physical or cognitive rest or provided empirical evidence supporting the graded return to activity progression. Valovich's main findings suggest that rest is underused by healthcare providers, recommendations for cognitive rest do not provide guidance for clinicians during individualized patient care. An initial period of moderate physical and cognitive rest may improve outcomes during the acute post-injury phase. A study done by Darling et al. (2014) combined the Buffalo Concussion Treadmill Test with the Zurich guidelines and the advice suggesting that light activity may be beneficial to recovery. In the end, it was concluded that high-quality prospective studies evaluating the influence of rest, early light exercise, and other treatment options are needed to provide an evidence-based road map for managing patients with sport-related concussions. "Until additional research has been published, it is prudent for clinicians to approach concussion management and return to activity in a conservative manner that evaluates the clinical presentation and the needs of each patient (Valovich et al., 2017)." This systematic review is of high quality based upon the CASP scale. This study had 7/8 answers as "Yes" or "Can't Tell" indicating that this article is of high quality. The weaknesses of this study included a lack of bias awareness and various levels of quality of research included in this review.

Todd et al. (2018) conducted a study to investigate the effect of concussions on psychiatric illness within athletes. Ryan Todd and his team conducted semi-structured interviews with 20 ice hockey players including minor and professional players. Concussions have been linked to major depressive disorders, generalized anxiety disorder, suicide, and other long-term

psychiatric diseases (Finkbeiner et al., 2016). Todd's study was done using the grounded approach theory to better understand what a hockey player experiences when suffering from a concussion. "Grounded theory is a method of systematically collecting data and analyzing data to construct theories that are grounded or are generated, in that data" (Boeije et al., 2002). This type of approach was believed to allow researchers to understand the different socio-cultural filters that hockey players apply to the concept of concussions and its management. Throughout these interviews, participants described a process in which some players undertook a biographical deconstruction when they experienced post concussive mental illness, which was amplified by isolation, stigma from peers, and a lack of a clear life trajectory. All the participants identified that they knew individuals in the hockey world who had mental illness. Many had stories revolving around isolating depressions, suicide, and post-concussive illness. Treatment modalities that facilitate and normalize this process, such as interpersonal psychotherapy, should be emphasized with this population. Future research could extend this methodology with other groups that experience a head injury. This case study is of low quality based upon the CASP scale. This study had 4/11 answers as "Yes" or "Can't Tell" indicating that this article is of low quality. The weaknesses of this study included a lack of minimizing bias, equal treatment of the patients between the different trials, and focused more on the role of the athlete's coaches, parents, and health professionals and not the health of the athlete.

"Baseline neuropsychological testing is mandated at various levels of play for hundreds of thousands each year (Randolph, 2011)." Christopher Randolph (2011) conducted a systematic review of the risks associated with sport-related concussion, and the clinical validity and reliability data for the most used baseline test, the ImPACT program. Despite the widespread use of baseline neuropsychological testing in the management of sport-related concussion, there

appears to be essentially no evidence in the medical literature to suggest that this approach has modified any associated risks. The baseline test used in sport-related concussion management programs lacks enough clinical validity and reliability for their intended purpose. Given the relatively low sensitivity and poor reliability of the ImPACT test, it is likely to result in a false negative at the same rate that it is likely to result in a false positive. A false negative could classify an athlete as recovered, when in fact he or she will still be experiencing cognitive impairment secondary to a concussion. The use of a baseline neurocognitive test with poor sensitivity and inadequate reliability in this context may lead to an unfounded sense of security that recovery has taken place and this is true especially for clinicians who lack training in psychometrics to understand the limitations of the ImPACT test. This systematic review is of high quality based upon the CASP scale. This study had 6/8 answers as "Yes" or "Can't Tell" indicating that this article is of high quality. The weaknesses of this study included a lack of a clearly focused question and instead focuses on baseline neuropsychological testing.

In 2013, consensus-based recommendations were that athletes should rest until symptom resolution before beginning physical activity (McCrory et al., 2013). However, consensus-based recommendations published in 2017 recommended that limited physical activity is safe before complete symptom resolution and that participation in symptom-limited exercise can be beneficial for concussion recovery (McCrory et al., 2017). Howell et al. (2018) conducted a review of the current understanding of the role of sub symptom exercise to improve outcomes after a concussion. The existing studies were divided into 3 groups: studies with no defined exercise prescription and no control group, studies with a defined exercise prescription and no control group, and studies with a defined exercise prescription and a control group. From the studies reviewed Howell et al. (2018) concluded that sub symptom aerobic exercise is a

beneficial treatment strategy for athletes after a concussion. This systematic review is of high quality based upon the CASP scale. This study had 7/8 answers as “Yes” or “Can’t Tell” indicating that this article is of high quality. Weaknesses of this study included a lack of all-important outcomes being considered for example the effect of training intensity, duration, frequency, or program duration within aerobic exercise programs on concussion recovery remains unknown.

The wide variety of interventions assessed in systematic reviews to date illustrates a large number of potential consequences from mTBI/concussion, the problems of identifying for each patient or groups of patients the key specific consequences of their injury, providing therapies that significantly improve those dysfunctions, and disentangling the individual effects of multiple therapies in studies which employ multiple interventions (Thomas et al., 2017). Thomas and his team (2017) wanted to identify all randomized clinical trials of therapy for concussion/mTBI; to identify interventions that had significant positive, negative or neutral outcomes and identify gaps in the literature for which further research was needed. 14 randomized clinical trials were included in their analysis. In the 14 trials, there were various interventions used including cognitive behavioral therapy and electronic devices following unique protocols. The trials that used cognitive behavioral therapy had significant positive changes on multiple outcome measures at $p<0.05$ or better. The trials that used the electronic devices had significant positive changes in outcome measures at $p<0.05$ or better. No study used in this review used the interventions of previous studies and improved them or tested them in different populations to increase generalizability. The authors of this systematic review had a lot of limitations on this study including varying definitions for what a mTBI/concussion is, which made the study populations non-comparable. This systematic review is of high quality based upon the CASP

scale. This study had 7.5/8 answers as “Yes” or “Can’t Tell” indicating that this article is of high quality. Weaknesses of this study included a lack of all-important outcomes being considered and only four of the studies included were randomized clinical trials.

Kelly et al. (2014) found that clinical practices in concussion management at NCAA Division I schools were generally in line with NCAA guidance, but could be improved in some cases through a more robust use of a multi-modal concussion examination. Buckley and colleagues (2015) had similar findings in a sample of NCAA Division II and III institutions. Baugh and her team (2017) aimed to understand whether, prior to the implementation of an evaluated mechanism, institutions’ concussion management plans included the components required by the NCAA Concussion Policy. Clinicians and compliance administrators were asked to send their school’s concussion management plans to the NCAA Sports Medicine Institute. This request was distributed to all 1,066 NCAA member-institutions. Only 137 concussion management plans were collected and only 125 plans were included in this study because of various issues. This study concluded that the majority of the schools’ concussion management plans included most, but not all the required elements. The component that the largest number of schools failed to include was the annual athlete education and athlete acknowledgment of their responsibility to report symptoms. Only a minority of concussion management plans specified that concussion education was to occur on an annual basis. This study provides baseline information that will assist in the evaluation of whether and to what extent the NCAA’s newly implemented process for reviewing concussion management plans has improved school’s compliance with NCAA requirements and whether it has translated into improved clinical practice. This cohort study is of high quality based upon the CASP scale. This study had 6.5/8 answers as “Yes” or “Can’t Tell” indicating that this article is of high quality. The weaknesses of

this study included a lack of minimizing bias and the authors not considering all-important confounding factors in the design and analysis.

Yorke et al. (2015) defined a concussion as a mild traumatic brain injury that may cause physical, cognitive, affective, and sleep dysfunction. Despite the wide availability of concussion information, reports of limited understanding and lack of following published guidelines by health care professionals continue to exist (Yorke et al., 2015). York et al. (2015) created a 55-question electronic survey that was divided into six sections: demographics, current practice in concussions, youth concussion legislation, attitudes and beliefs toward concussion management, concussion knowledge, and clinical decision making. The survey was distributed through selected American Physical Therapy Association sections. A total of 1,272 physical therapists completed the survey. 70% of respondents reported having concussion training and respondents correctly answered, on average, 13 of the 15 concussion knowledge questions. Gaps were found in understanding the clinical utilization of concussion severity scales, conservative treatment of youth who sustain a concussion and identifying a need for vestibular or manual physical therapy. Yorke and her colleagues (2015) recommended that future professional development opportunities should be developed to target identified gaps in knowledge and current practice patterns. This cohort study is of high quality based upon the CASP scale. This study had 6/8 answers as “Yes” or “Can’t Tell” indicating that this article is of high quality. The weaknesses of this study included a lack of measuring bias exposure and the outcome was not measured to minimize bias.

Individuals with a concussion often complain of persistent dizziness and imbalance, which can be treated with vestibular rehabilitation exercises (Alsalaheen et al., 2012). Alsalaheen et al. (2012) conducted a study to describe vestibular rehabilitation exercises prescriptions

provided to individuals after a concussion. Alsalaheen and his team (2012) completed a retrospective chart review of vestibular rehabilitation home exercise programs that were prescribed by physical therapists for 104 patients diagnosed with a concussion. Each exercise was classified by exercise type, duration, and frequency. Alsalaheen et al. (2012) concluded that eye-head coordination exercises were the most prescribed exercise type, followed by standing static balance exercises and ambulation exercises. By knowing the preferred prescription and progression pattern of exercises employed by expert physical therapists, other clinicians initiating a vestibular rehabilitation treatment program for individual's post-concussion may have a foundation to guide their intervention. This cohort study is of high quality based upon the CASP scale. This study had 6.5/8 answers as "Yes" or "Can't Tell" indicating that this article is of high quality. The weaknesses of this study included a lack of the authors identifying all-important confounding factors in the design and analysis.

The level of scientific research and media coverage regarding the topic of sports concussion has virtually exploded over the last 20 years (Guay et al., 2016). For example, using the search term "sports-related concussion" to access scientific articles from various sources yielded 33 studies from 1980 to 2000, and 905 studies from 2001 to 2014, with 234 studies published from 2014 to 2016 alone. Guay and her colleagues (2016) conducted a systematic review to summarize the latest research findings in sport-related concussions and the ways that multiple disciplines within psychology can continue to play a critical role in enhancing patient care. Guay et al. (2016) discovered that there are many guidelines regarding the management of sport-related concussions, including those proposed by the American Academy of Neurology (AAN), the National Athletic Training Association (NATA), the American Medical Society for Sports Medicine (AMSSM), and the consensus statement of the 4th International Conference on

Concussion in Sport. There were some minor differences among the various guidelines, but common themes existed. Athletes should be given an individualized graded physical activity plan. The plans should allow for a gradual increase in physical exertion and activity as recovery is observed over time. Makdissi et al. (2013) reviewed the literature on prolonged concussion symptoms (> 10 days) to provide recommendations for management. The findings indicated that more complex cases require multidisciplinary care, including physical and cognitive rest, various therapies including vestibular, occupational, and cognitive rehabilitation, psychological treatment, and a graded exercise program. During the acute state of a concussion, there is often a recommendation for cognitive and physical rest, based on the "metabolic mismatch" principle (Grady et al., 2012). The metabolic mismatch principle is when high metabolic brain needs, energy production and the availability of fuel substrate for energy production are both simultaneously decreased. However, a recommendation for strict rest for prescribed periods has been called into question by a recent randomized study of concussed individuals between the ages of 11 and 22 (Thomas et al., 2015). In this study, the strict rest group reported more post-concussion symptoms and slower symptom reduction than the one to two days of rest group (Thomas et al., 2015). This systematic review is of high quality based upon the CASP scale. This study had 6/8 answers as "Yes" or "Can't Tell" indicating this article is of good quality. The weaknesses of this study included a lack of addressing a clearly focused question and lack of all-important outcomes being considered.

The management of sports-related concussion (SRC) has evolved (Popovich et al., 2019). The initial period of rest can range widely, with some athletes being withheld from exercise for weeks or months depending on the duration of their symptoms (Neurology, 1997). Recent studies have now suggested that normal daily activities after SRC are safe and may speed

recovery compared to strict rest. Michael Popovich and his colleagues (2019) conducted a retrospective cohort study to assess the safety of supervised exercise in acute sport-related concussion and its influence on recovery. A total of 126 patients were included in the analysis. The participants were placed into an early sports exercise (SE) group and a non-early sports exercise group. The early SE cohort was defined as those patients who underwent SE in a clinic within 16 days of injury while still experiencing ongoing symptoms of sport-related concussion. Popovich et al. (2019) concluded that athletes who are still acutely symptomatic following a sport-related concussion are safe to begin early sports exercise and the exercise is expected to be well-tolerated, and the exercise may improve recovery. Furthermore, exercise has been associated with a reduction in psychiatric symptoms (Jayakody et al., 2014). Popovich and his colleagues (2019) suggest that returning to exercise soon after a sport-related concussion, can help athletes reduce post-injury anxiety and depression. This cohort study is of high quality based upon the CASP scale. This study had 7/8 answers as "Yes" or "Can't Tell" indicating that this article is of high quality. Weaknesses of this study included a lack of minimizing bias and not all the patients received the same treatment.

A sport-related concussion is an important condition that can affect collegiate and professional athletes (Ellis et al., 2018). Ellis et al. (2018) felt the current recommendations place little emphasis on the rapid physical deconditioning that occurs in athletes within days of exercise cessation or the pathophysiological processes responsible for acute concussion symptoms that can be successfully targeted by evidence-based rehabilitation strategies. Ellis et al. (2018) talked about the dangers deconditioning can have on athletes and how abrupt cessation of physical exercise can lead to rapid declines in cardiovascular, metabolic functioning, and pronounced performance loss. Ellis et al. (2018) recommended a physiological approach to acute

concussion assessment and management. It all starts with providing a definitive medical diagnosis, identifying the clinic-pathophysiological features that may place the athlete at risk of prolonged recovery, and informing the development of an individually tailored rehabilitation program that targets the pathophysiological causes of concussion symptoms while maintaining the athlete's physical fitness level during the recovery process. Ellis and his colleagues (2018) would provide this information on what they learn from the athlete's clinical history, a physical exam, supplemental diagnostic testing, and graded aerobic exercise testing. Based on what they discover they will begin to design an individually tailored rehabilitation program. The three key pathophysiological processes that are most frequently targeted following acute concision are: autonomic dysfunction and exercise tolerance, vestibulocochlear dysfunction, and cervical spine dysfunction (Ellis et al., 2018). Combining the results of a comprehensive clinical history, physical examination, and graded aerobic exercise testing, this approach allows clinicians to work together to develop an individually-tailored program that promotes the active rehabilitation of acute concussion while minimizing physiological deconditioning (Ellis et al., 2018). This systematic review is of high quality based upon the CASP scale. This study had 7/8 answers as "Yes" or "Can't Tell" indicating that this article is of high quality. The weaknesses of this study included a lack of authors assessing the quality of the included studies.

A sport-related concussion is a significant public health problem without an effective treatment (Leddy et al., 2019). Leddy and his colleagues (2019) wanted to assess the effectiveness of sub symptom threshold aerobic exercise versus a placebo-like stretching program prescribed to adolescents in the acute phase of recovery from sport-related concussions. A total of 103 male and female adolescents' athletes ranging from ages 13-18 presenting within 10 days of a sport-related concussion were randomly assigned to aerobic exercise or a placebo-

like stretching regimen. The aerobic exercise participants recovered in a median of 13 days, whereas stretching participants recovered in 17 days. This study was the first randomized controlled trial to show that individualized sub symptom threshold aerobic exercise treatment prescribed to adolescents with concussion symptoms during the first week after sport-related concussion speeds recovery and may reduce the incidence of delayed recovery. This randomized controlled trial is of high quality based upon the CASP scale. This study had 8/9 answers as "Yes" or "Can't Tell" indicating that this article is of high quality. The weaknesses of this study included a lack of blinding for participants for the treatments. Also, this study did not address the mechanisms responsible for the beneficial effect of exercise after a concussion. This study only included high school athletes and future studies should test collegiate and professional athletes. This would allow some clarification to see if age is a factor that should be considered in making a concussion rehabilitation plan.

Chapter IV

Discussion

Early research recommended physical and cognitive rest, suggesting that exercising while recovering from concussions prolonged symptoms. Guskiewicz et al. (2004) and Broglio et al. (2014) created a National Athletic Trainers Association position statement that stated rest was the best practice for concussion recovery. Patients were instructed to avoid any physical or mental exertion during the acute stage. Meehan III et al. (2011) and Broglio et al. (2015) stated physical and cognitive rest was the most common rehabilitation approach.

The latest research as of 2019 recommends taking a more active approach when creating a rehabilitation program for athletes who have suffered a concussion or traumatic brain injury. Popovich et al. (2019) assessed the safety of supervised exercise (SE) in acute sport-related concussions (SRC) and its influence on recovery. Leddy et al. (2019) assessed the effectiveness of sub symptom threshold aerobic exercise vs a placebo-like stretching program prescribed to adolescents in the acute phase of recovery from a sport-related concussion. Howell et al. (2018) assessed if sub symptom aerobic exercise was a beneficial treatment strategy for athletes after a concussion. These studies provide early evidence of the future of concussion and traumatic brain injury rehabilitation and management. The debate between physical and cognitive rest versus active recovery is still far from over but the above-mentioned research is finally providing evidence for promoting physical activity for athletes suffering from a sport-related concussion. The current gap in literature includes a consistent definition of what a concussion is, when do you start the exercise program, and is the exercise program the best form of treatment for all demographics.

Implications

Concussion treatment and rehabilitation are particularly important in the field of athletic training, especially ones that work in an educational setting such as high schools and colleges. Athletic trainers have the responsibility to treat these athletes from an athletic standpoint, as well as, an educational one. Student-athletes have busy schedules and the last thing they want to do is fall behind in school and miss time with their teams. With the early research suggesting athletes needed to just rest physically and cognitively, for the student-athlete that meant a loss of education and isolation from their friends and teammates. Randolph (2011) stated The ImPACT tests, is a commonly used concussion tool that lacks sufficient clinical validity and reliability for its intended purpose. The use of a baseline neurocognitive test with poor sensitivity and inadequate reliability may lead to an unfounded sense of security that recovery has taken place. Continued research and education for athletic trainers is needed to able be to help the student-athletes return to the classroom and the field quicker and limit the chance of repeat concussions.

Trends and Gaps in the Literature

There is still a lack of knowledge about the best way to treat sports-related concussions and traumatic brain injuries. Much like any injury, healthcare practitioners should approach every concussion on an individualized basis, but we can at least begin to create a generalized process for healthcare providers customized for concussed athletes. The latest research recommends allowing physical and cognitive rest during the acute stages of a concussion, which can be around the initial one to three days. The program should be focused on getting the athlete back into the classroom before getting them back onto their sport. The athlete should continue their school schedule as normal; it can be modified if needed to include half days and a modified workload. Once we can manage the athlete's school workload, the next step would be to begin

introducing the athlete into a supervised exercise program. The athlete would begin on a stationary bike at a low intensity. Heart rate, perceived exertion, and self-reported symptom severity would be recorded every two minutes. The intensity would be gradually increased as tolerated every two to four minutes and the exercise program should be stopped after 20 minutes. If symptoms worsen the intensity should be decreased. If symptoms do not improve when the intensity is decreased the supervised exercise should be stopped. This process can be repeated when the athlete's symptoms improve or return to the levels they were already at. The hope is that the athlete continues to exercise longer and more intense without increasing symptom severity. Once the athlete can tolerate exercise on the stationary bike they may progress to an elliptical or treadmill. The athletes' physical and cognitive abilities should be monitored until they are symptom-free. Once they are symptom-free, the athlete would continue the return to play progression which is taken from the Zurich Guidelines made by McCrory et al. (2012) which is a graded return to play program. Step one: the athlete being able to handle their normal school load without aggravating any symptoms. Step two: the athlete should be able to complete light aerobic exercise on a stationary bike or treadmill for five to ten minutes without aggravating symptoms. Step three: putting the athlete through sport-related exercises or activities without aggravating any symptoms. The sport related exercise should be done on a stationary bike or treadmill and their heartrate should be kept below 80% of their target heart rate while exercising to start. They should progress until they are able to handle 100 % of their target heart rate without aggravating symptoms. Step four: The athlete should return to practice on a non-contact basis. Step five: The athlete can return to a full participant in practice including contact. Step six: The athlete may return as a full participant including competition and games. If the

athlete has a return of symptoms during any of these steps, they should return to the previous step until completion of that step.

Future Research

Future research should include higher amounts of participants and higher-quality prospective studies that have consistent parameters and targeted rehabilitation strategies. Thomas et al. (2017) recommended more consistency is needed between studies including definitions of both a mild traumatic brain injury and concussion. Future research should require a minimal sample size requirement, it should be built off previous research and should have similar outcome measurements so they can be compared. Howell et al. (2018) suggested future studies should assess the causal effects pertaining to concussion recovery, the specific parameters of an exercise program, and the association between symptom resolution with psychosocial and physiologic function. Leddy et al. (2018) suggested further research to examine the optimal timing and dose of guided aerobic exercise for the active treatment of concussion, along with its potential to prevent persistent post-concussive symptoms. Popovich et al. (2019) even had the idea for future research to consider tracking a patient's activities at home using continuous activity monitoring.

Conclusion

Based on the 19 articles that were reviewed active recovery provides a faster reduction in symptoms and a faster return to play for college athletes compared to conservative rest after suffering a concussion. There is still a lot that needs to be learned including the optimal timing and doses of the guided exercise. These results are very promising and should begin to be worked into athletic training programs unless future research says otherwise. Active recovery is

expected to continue to return athletes sooner and reduce symptoms faster for all athletes after suffering a sport-related concussion there just needs to be more consistent research across more demographics to provide support for active recovery concussion rehabilitation programs.

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Appendix A

Article	Purpose	Sample	Design	Measurments	Results/Conclusion	Recommendations	Level & Quality
Guskiewicz, K. M., Bruce, S. L., Cantu, R. C., Ferrara, M. S., Kelly, J. P., McCrea, M. M., ... Putukian, M. (2004). National Athletic Trainers' Association Position Statement: Management of Sport-Related Concussion. *Journal of Athletic Training*, *39*(3), 280-297. Retrieved from https://www.quickbase.com/blog/three-types-of-change-management-models	This position statement should provide valuable information and recommendations for the certified athletic trainer, physicians, and other medical professionals caring for athletes at the youth, high school, collegiate and elite levels.	N/A	Systematic Review	N/A	Avoid taking medications except for acetaminophen. Avoid alcohol, illicit drugs, or other substances that might interfere with cognitive function and neurological recovery. The rest should be instructed but not complete bed rest. Eat a well-balanced diet	The athlete should resume normal activities of daily living as tolerated while avoiding activities that potentially increase symptoms. Once he or she is symptom-free the athlete may resume a graded program of physical and mental exertion, without contact or risk of concussion	Level of Evidence: V Quality: High (7/8)

Guskiewicz, K. M., Bruce, S. L., Cantu, R. C., Ferrara, M. S., Kelly, J. P., McCrea, M. M., ... Putukian, M. (2004). National Athletic Trainers' Association Position Statement: Management of Sport-Related Concussion. *Journal of Athletic Training*, *39*(3), 280-297. Retrieved from https://www.quickbase.com/blog/three-types-of-change-management-models	This position statement should provide valuable information and recommendations for the certified athletic trainer, physicians, and other medical professionals caring for athletes at the youth, high school, collegiate and elite levels.	N/A	Systematic Review	N/A	Avoid taking medications except for acetaminophen. Avoid alcohol, illicit drugs, or other substances that might interfere with cognitive function and neurological recovery. The rest should be instructed but not complete bed rest. Eat a well-balanced diet	The athlete should resume normal activities of daily living as tolerated while avoiding activities that potentially increase symptoms. Once he or she is symptom-free the athlete may resume a graded program of physical and mental exertion, without contact or risk of concussion	Level of Evidence: V Quality: High (7/8)

Broglio, S. P., Collins, M. W., Williams, R. M., Mucha, A., & Kontos, A. (2015, April). Current and Emerging Rehabilitation for Concussion: A Review of the Evidence. *Clinical Sports Medicine*, *34*(2), 213-231. doi: 10.1016/j.csm.2014.12.005	This review evaluates the current literature for evidence for and against physical and cognitive rest and emerging areas targeting vestibular, oculomotor, and pharmacological interventions for the rehabilitation of sport-related concussion	Athletes who had suffered a sport-related concussion	Systematic review	Results from studies testing physical and cognitive rest versus emerging vestibular, oculomotor and pharmacological interventions	Physical and cognitive rest is the most common rehab approach	More active and targeted rehab strategies including vestibular and oculomotor rehab and pharmacological interventions have emerging evidence supporting their use	Level of Evidence: I Quality: High (8/8)

Meehan III, W. P. (2011, January). Medical Therapies for Concussion. *Clinical Sports Medicine*, *30*(1), 115-ix. doi: 10.1016/j.csm.2010.08.003	This review discusses therapies investigate for the treatment of functional traumatic brain injury, not solely those initially labeled as mild	Current and past Sport-related concussion management therapies	Systematic review	Effectiveness of common recommendations, therapies, and medication	Overview of most common therapies including physical and cognitive rest, mixed results on medications, but could help with the depression aspect of concussions.	Cognitive rehab is unnecessary and of doubtful benefit. Evidence to support the use of methylphenidate.	Level of Evidence: I Quality: Moderate (4.5/8)

Leddy, J. J., Haider, M. N., Ellis, M., & Willer, B. S. (2018, August). Exercise is Medicine for Concussion. *American College of Sports Medicine*, *17*(8), 262-270. Retrieved from file:///C:/Users/trobe/Downloads/Exercise_is_Medicine_for_Concussion.5.pdf	The purpose of this article is to review the evidence for the use of controlled aerobic exercise as medicine for the treatment of concussion and persistent post-concussive symptoms	Patients with persistent post-concussive symptoms	Systematic review	Effects of the buffalo concussion treadmill test on increasing a patient's heart rate and its effects on speeding up recovery from a concussion.	The latest concussion in sports group consensus guidelines recommend a more active approach to sport-related concussion treatment and there is emerging evidence for the potential effectiveness of controlled aerobic exercise in the acute phase after a sport-related concussion.	Further research should examine the optimal timing and dose of guided aerobic exercise for the active treatment of concussion, its potential to prevent PPCS and more thoroughly investigate the physiological and neurophysiological mechanisms for its effects	Level of Evidence: I Quality: High (7.5/8)

Leddy, J. J., Kozlowski, K., Fung, M., Pendergast, D. R., & Willer, B. (2007). Regulatory and Autoregulatory Physiological Dysfunction as a Primary Characteristics of Post-Concussion Syndrome: Implications for Treatment. *Neurorehabilitation*, *22*, 199-205. Retrieved from https://coe.uoregon.edu/cds/files/2018/06/Leddy_Regulatory-and-autoregulatory-physiological-dysfunction-as-a-primary-characteristic-of-post-concussion-syndrome_-Implications-for-treatment_NeuroRehab_2	To review the metabolic and physiologic changes and to bring together the available research into a theory to explain why post-concussion syndrome occurs	Humans and animals	Systematic Review	Amount of physiologic reduction or alleviation after participating in an individualized controlled sub-symptoms threshold aerobic exercise rehab	We recommend that the exercise rehab of post-concussion symptom patients be an individualized, progressive sub-symptom threshold aerobic exercise program	Any research on treatment should look at the efficacy of a controlled exercise rehab program and the exact conditions required for the optimization of the use of exercise to help the injured brain in patients with PCS	Level of Evidence: I Quality: High (7/8)

Burke, M. J., Fralick, M., Nejatbakhsh, N., Tartaglia, M. C., & Tator, C. H. (2014). In Search of Evidence-Based Treatment for Concussion: Characteristics of Current Clinical Trials. *Brain Injury*, *29*(3), 300-305. doi:10.3109/02699052.2014.974673	To assess the characteristics of current clinical trials investigating the treatment of concussion, focusing on study demographics, methodologies, target population, outcome measures, and types of interventions.	Concussion/mild traumatic brain injury interventional clinical trials	Systematic Review	Current clinical trials and types of therapy being used	Current treatments being tested include cognitive/behavioral therapies, medications, devices, dietary supplements, return to activity/rest, and others.	It is suggested that more appropriately targeted research efforts with enhanced methodological rigor are required to adequately address the ongoing need for evidence-based treatment of concussion.	Level of Evidence : V Quality: Moderate (4.5/8)

Valovich McLeod, T. C., Lewis, J. H., Whelihan, K., & Bacon, W. (2017). Rest and Return to Activity After Sport-Related Concussion: A Systematic Review of the Literature. *Journal of Athletic Training*, *52*(3), 262-287. doi:10.4085/1052-6050-51.6.06	To systematically review the literature regarding rest and return to activity after sport-related concussion	Studies in English and evaluated the effectiveness of physical or cognitive rest of provided empirical evidence supporting the graded return to activity progression	Systematic Review	Use of rest, rest effectiveness, compliance with recommendations, or outcome after graded return to activity progression	Physical rest and cognitive rest were underused by health care providers. Moderate physical and cognitive rest may facilitate recovery during the initial days after a concussion. Little evidence supports the effectiveness of the graded return to play progression	High-quality prospective studies evaluating the influence of rest, early light exercise, and other treatment options are needed to provide an evidence-based road map for managing patients with sport-related concussion	Level of Evidence : I Quality: High (7/8)

Todd, R., Bhalerao, S., Vu, M. T., Soklaridis, S., & Cusimano, M. D. (2018). Understanding the Psychiatric effects of Concussion on Constructed Identity in Hockey Players: Implications for Health Professionals. *PLO S ONE*, *13*(2), 1-16. Retrieved from https://doi,org/10.1371/journal.pone.0192125	To investigate the effect of concussion and psychiatric illness on athletes and their caregivers	20 ice hockey players. 17 men and 3 women	Case Study	Effects of concussion and psychiatric illness	Some athletes underwent a biographical deconstruction when they experienced post-concussive mental illness, which was amplified by isolation, stigma from peers, and lack of a clear life trajectory	Interpersonal psychotherapy that focuses on role transitions may create opportunities to facilitate the process of biographical reconstruction and life transition.	Level of Evidence: IV Quality: Low (4/11)

Randolph, C. (2011, January). Baseline Neuropsychological Testing in Managing Sport-Related Concussion: Does it Modify Risk? *Current Sports Medicine Reports*, *10*(1), 21-26. doi:10.1249/JSR.obo13e318207831d	Reviews the risks associated with sport-related concussion, and clinical validity and reliability data for the ImPACT program.	Athletes who have had complicates from concussions or have been cleared to play too soon after suffering a concussion and took the ImPACT test	Systematic Review	Validity and reliability of baseline neuropsychological testing	The ImPACT program lacks sufficient clinical validity and reliability for its intended purpose.	The use of a baseline neurocognitive test with poor sensitivity and inadequate reliability may lead to an unfounded sense of security that recovery has taken place.	Level of Evidence: I Quality: High (6/8)

Howell, D. R., Taylor, A. J., Ozan Tan, C., Orr, R., & Meehan III, W. P. (2018). The Role of Aerobic Exercise in Reducing Persistent Sport-Related Concussion Symptoms. *Medicine & Science in Sports & Exercise*, 647-652. doi:10.1249MSS.0000000000001829	This review will provide a summary of the current understanding of the role of sub symptom exercise to improve outcomes after a concussion and will describe the exercise parameters that appear to be important.	Athletes that suffered a concussion	Systematic Review	Exercise effects on self-reported symptoms	Sub symptom aerobic exercise is a beneficial treatment strategy for athletes after a concussion. But the effect of training intensity, duration, frequency, or program duration remains unknown	Future studies are required to assess the causal effects pertaining to concussion recovery, namely, the specific parameters of an exercise program and the association between symptom resolution with psychosocial function, physiologic function, or a combination of these factors.	Level of Evidence: I Quality: High (7/8)

Thomas, R. E., Alves, J., Vaska, M. M., & Magalhaes, R. (2017). Therapy and Rehabilitation of Mild Brain Injury/Concussion: Systematic Review. *Restorative Neurology and Neuroscience*, *35*, 643-666. doi:10.3233/RNN-170761	Identify all randomized controlled trials (RCT's) of mild traumatic brain injury/concussion therapy, risks of bias and therapies with significant positive results	16 RCT's	Systematic Review	Types of therapy/rehabilitation and its effects on athletes recovering from a mild traumatic brain injury.	Of the many RCT's reviewed due to different definition of mTBI/Concussion made it difficult to compare studies and none of the authors built off previous work or authors. 3 studies recommended rest and 12 recommended treatment	More consistency is needed between studies including definitions of what a mild traumatic brain injury or concussion is. Along with minimal sample size requirements and working off previous work and outcome measurement requirements.	Level of Evidence: I Quality: High (7.5/8)

Baugh, C. M., Kroshus, E., Perry, K. I., & Bourlas, A. P. (2017). Concussion Management Plans' Compliance with NCAA Requirements: Preliminary Evidence Suggesting Possible Improvement. *The Journal of Law, Medicine & Ethics*, *45*, 231-237. doi:10.1177/1073110517720652	To understand whether, prior to the implementation of an evaluative mechanism, institutions' concussion management plans included the components required by the NCAA Concussion Policy	125 NCAA institutions	Cohort Study	Quality of Concussion protocol	65% of plans included athlete concussion education and athlete responsibility to report concussion symptoms. But only 30% of plans specified that this process occurs annually.	This study provides baseline information that will assist in the evaluation of whether and to what extent the NCAA's newly implemented process for reviewing concussion management plan has improved plans' compliance with NCAA requirements and whether it has translated into improved clinical practice.	Level of Evidence : III Quality: High 6.5/8

Yorke, A. M., Littleton, S., & Alsalaheen, B. A. (2015, July). Concussion Attitudes and Beliefs, Knowledge, and Clinical Practice: Survey of Psychical Therapists. *Physical Therapy*, *96*(7), 1018-1028.	To describe the current attitudes and beliefs, knowledge, and practice of physical therapists in the treatment of patients with concussion	1,272 physical therapists	Cohort Study	Physical Therapist's knowledge of concussion management and concussion protocol.	70% of the respondents reported having concussion training. Respondents demonstrated variability in identifying a need for vestibular or manual physical therapy.	Convenience sampling was used. Future opportunities should be developed to target identified gaps in knowledge and current practice patterns	Level of Evidence: III Quality: High (6/8)

Alsalaheen, B. A., Whitney, S. L., Mucha, A., Morris, L. O., Furman, J. M., & Sparto, P. J. (2012, May 10). Exercise Prescription Patterns in Patients Treated with Vestibular Rehabilitation After Concussion. *Physio therapy*, *18*, 100-108.	To describe the vestibular rehabilitation exercise prescriptions provided to individuals after a concussion	104 participants who were diagnosed with a concussion	Retrospective chart review (cohort study)	Amount of times the specific rehab exercises were prescribed	Eye-head coordination exercises were the most prescribed exercise type followed by standing static balance exercises and ambulation exercises	Future research should include prescription patterns and should be directed to relate to the exercise prescription patterns	Level of Evidence: V Quality: High (6.5/8)

Guay, J. L., Lebretore, B. M., Main, J. M., DeFrangesco, K. E., Taylor, J. L., & Amedoro, S. M. (2016). The Era of Sport Concussion: Evolution of Knowledge, Practice, and the Role of Psychology. *American Psychologist*, *71*(9), 875-887. doi:10.1037/a0040430	To summarizes the latest research findings on sport concussion.	Athletes who have suffered one or multiple concussion	Systematic Review	The latest research on concussion and concussion management	Rest is indicated in the acute stages of a concussion. Concussions lasting longer than 10 days indicate physical and cognitive rest, various therapies, psychological treatment, and graded exercise program Strict rest should not be the gold standard	Despite prolific research efforts, one of the most important unanswered questions in sports concussion research is "what are the specific factors that predict prolonged recovery or negative long-term outcomes in some individuals?"	Level of Evidence: Level I Quality: High (6/8)

Popovich, M., Almeida, A., Freeman, J., Eckner, J. T., Alsalaheen, B., Lorincz, M., & Sas, A. (2019). Use of Supervised Exercise During Recovery Following Sports-Related Concussion. *Clinical Journal of Sports Medicine*, 1-6. doi:10.1097/JSM.0000000000000721	To assess the safety of supervised exercise (SE) in Acute sport-related concussion (SRC) and its influence on recovery.	126 patients records	Retrospective cohort study	Association between early supervised exercise and clearance for return to sport. The number of days from a sport-related concussion until clearance for return to sport and the number of days symptomatic from a concussion.	No serious adverse events occurred in those completing early sports exercise. Early sports exercise was associated with earlier clearance for return to sport. The early sports exercise group was cleared for return to their sport in fewer days	Future studies may consider tracking activities at home by using continuous activity monitoring	Level of Evidence: III Quality: High (7/8)

Ellis, M. J., Leddy, J., Cordingley, D., & Willer, B. (2018, December 20). A Physiological Approach to Assessment and Rehabilitation of Acute Concussion in Collegiate and Professional Athletes. *Hypothesis and Theory*, *9*(1115), 1-14. doi:10.3389/fneur.2018.01115	To assess if clinical manifestations of acute concussion are caused by heterogeneous pathophysiological processes	Collegiate and professional athletes with acute concussions	Systematic Review	Clinical history, physical examination and aerobic exercising and comparing the amount of time until final return to play	Combining the results of a comprehensive clinical history, physical examination, and graded aerobic exercising testing. This approach allows clinicians to work together to develop an individually tailored program that promotes the active rehabilitation of acute concussion while minimizing physiological deconditioning.	This approach will undoubtedly require further refinement as novel insights into the pathophysiology and evidence-based management of concussion become available in the future	Level of Evidence: I Quality: High (7/8)

Leddy, J. J., Haider, M. N., Ellis, M. J., Mannix, R., Darling, S. R., Freitas, M. S., ... Willer, B. (2019, February 4). Early Subthreshold Aerobic Exercise for Sport-Related Concussion A Randomized Clinical Trial. *JAMA Pediatrics*, 1-7. doi:10.1001/jamapediatrics.2018.4397	To assess the effectiveness of sub symptom threshold aerobic exercise vs a placebo-like stretching program prescribed to adolescents in the acute phase of recovery from sport-related concussion	103 male and female adolescent athletes from ages 13-18 presenting within 10 days of a sport-related concussion.	Multicenter prospective randomized clinical trial	Days from injury to recovery	Aerobic exercise participants recovered in a median of 13 days and the stretching participants recovered in a median of 17 days There was also a tendency for aerobic exercise to also prevent some adolescents from having a delayed recovery	Larger prospective studies should investigate mechanisms of action of aerobic exercise on the concussed brain and determine if prescribed early subthreshold exercise prevents some patients from having delayed recovery after concussion	Level of Evidence : II Quality: High (8/9)

Appendix B (Systematic Review)

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Paper for appraisal and reference:.....

Section A: Are the results of the review valid?

1. Did the review address a clearly focused question?

Yes ☐
Can't Tell ☐
No ☐

HINT: An issue can be 'focused' In terms of
- the population studied
- the intervention given
- the outcome considered

Comments:

2. Did the authors look for the right type of papers?

Yes ☐
Can't Tell ☐
No ☐

HINT: 'The best sort of studies' would
- address the review's question
- have an appropriate study design (usually RCTs for papers evaluating interventions)

Comments:

Is it worth continuing?

3. Do you think all the important, relevant studies were included?

Yes ☐
Can't Tell ☐
No ☐

HINT: Look for
- which bibliographic databases were used
- follow up from reference lists
- personal contact with experts
- unpublished as well as published studies
- non-English language studies

Comments:

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4. Did the review's authors do enough to assess quality of the included studies?

Yes ☐
Can't Tell ☐
No ☐

HINT: The authors need to consider the rigour of the studies they have identified. Lack of rigour may affect the studies' results ("All that glisters is not gold" Merchant of Venice – Act II Scene 7)

Comments:

5. If the results of the review have been combined, was it reasonable to do so?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider whether
- results were similar from study to study
- results of all the included studies are clearly displayed
- results of different studies are similar
- reasons for any variations in results are discussed

Comments:

Section B: What are the results?

6. What are the overall results of the review?

HINT: Consider
- If you are clear about the review's 'bottom line' results
- what these are (numerically if appropriate)
- how were the results expressed (NNT, odds ratio etc.)

Comments:

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7. How precise are the results?

HINT: Look at the confidence intervals, if given

Comments:

Section C: Will the results help locally?

8. Can the results be applied to the local population?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider whether
- the patients covered by the review could be sufficiently different to your population to cause concern
- your local setting is likely to differ much from that of the review

Comments:

9. Were all important outcomes considered?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider whether
- there is other information you would like to have seen

Comments:

10. Are the benefits worth the harms and costs?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- even if this is not addressed by the review, what do **you** think?

Comments:

Appendix C (Cohort)

CASP
Critical Appraisal Skills Programme

Paper for appraisal and reference:.....

Section A: Are the results of the study valid?

1. Did the study address a clearly focused issue?

Yes ☐
Can't Tell ☐
No ☐

HINT: A question can be 'focused' in terms of
- the population studied
- the risk factors studied
- is it clear whether the study tried to detect a beneficial or harmful effect
- the outcomes considered

Comments:

2. Was the cohort recruited in an acceptable way?

Yes ☐
Can't Tell ☐
No ☐

HINT: Look for selection bias which might compromise the generalisability of the findings:
- was the cohort representative of a defined population
- was there something special about the cohort
- was everybody included who should have been

Comments:

Is it worth continuing?

CASP
Critical Appraisal Skills Programme

3. Was the exposure accurately measured to minimise bias?

Yes ☐
Can't Tell ☐
No ☐

HINT: Look for measurement or classification bias:
- did they use subjective or objective measurements
- do the measurements truly reflect what you want them to (have they been validated)
- were all the subjects classified into exposure groups using the same procedure

Comments:

4. Was the outcome accurately measured to minimise bias?

Yes ☐
Can't Tell ☐
No ☐

HINT: Look for measurement or classification bias:
- did they use subjective or objective measurements
- do the measurements truly reflect what you want them to (have they been validated)
- has a reliable system been established for detecting all the cases (for measuring disease occurrence)
- were the measurement methods similar in the different groups
- were the subjects and/or the outcome assessor blinded to exposure (does this matter)

Comments:

CASP
Critical Appraisal Skills Programme

5. (a) Have the authors identified all important confounding factors?

Yes ☐
Can't Tell ☐
No ☐

HINT:
- list the ones you think might be important, and ones the author missed

Comments:

5. (b) Have they taken account of the confounding factors in the design and/or analysis?

Yes ☐
Can't Tell ☐
No ☐

HINT:
- look for restriction in design, and techniques e.g. modelling, stratified-, regression-, or sensitivity analysis to correct, control or adjust for confounding factors

Comments:

6. (a) Was the follow up of subjects complete enough?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- the good or bad effects should have had long enough to reveal themselves
- the persons that are lost to follow-up may have different outcomes than those available for assessment
- in an open or dynamic cohort, was there anything special about the outcome of the people leaving, or the exposure of the people entering the cohort

6. (b) Was the follow up of subjects long enough?

Yes ☐
Can't Tell ☐
No ☐

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Comments:

Section B: What are the results?

7. What are the results of this study?

HINT: Consider
- what are the bottom line results
- have they reported the rate or the proportion between the exposed/unexposed, the ratio/rate difference
- how strong is the association between exposure and outcome (RR)
- what is the absolute risk reduction (ARR)

Comments:

8. How precise are the results?

HINT:
- look for the range of the confidence intervals, if given

Comments:

CASP
Critical Appraisal Skills Programme

9. Do you believe the results?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- big effect is hard to ignore
- can it be due to bias, chance or confounding
- are the design and methods of this study sufficiently flawed to make the results unreliable
- Bradford Hills criteria (e.g. time sequence, dose-response gradient, biological plausibility, consistency)

Comments:

Section C: Will the results help locally?

10. Can the results be applied to the local population?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider whether
- a cohort study was the appropriate method to answer this question
- the subjects covered in this study could be sufficiently different from your population to cause concern
- your local setting is likely to differ much from that of the study
- you can quantify the local benefits and harms

Comments:

11. Do the results of this study fit with other available evidence?

Yes ☐
Can't Tell ☐
No ☐

Comments:

CASP
Critical Appraisal Skills Programme

12. What are the implications of this study for practice?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- one observational study rarely provides sufficiently robust evidence to recommend changes to clinical practice or within health policy decision making
- for certain questions, observational studies provide the only evidence
- recommendations from observational studies are always stronger when supported by other evidence

Comments:

Appendix D (Case Control)

CASP
Critical Appraisal Skills Programme

Paper for appraisal and reference:.....

Section A: Are the results of the trial valid?

1. Did the study address a clearly focused issue?

Yes ☐
Can't Tell ☐
No ☐

HINT: An issue can be 'focused' In terms of
- the population studied
- Whether the study tried to detect a beneficial or harmful effect
- the risk factors studied

Comments:

2. Did the authors use an appropriate method to answer their question?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- Is a case control study an appropriate way of answering the question under the circumstances
- Did it address the study question

Comments:

CASP
Critical Appraisal Skills Programme

Is it worth continuing?

3. Were the cases recruited in an acceptable way?

Yes ☐
Can't Tell ☐
No ☐

Comments:

HINT: We are looking for selection bias which might compromise validity of the findings
- are the cases defined precisely
- were the cases representative of a defined population (geographically and/or temporally)
- was there an established reliable system for selecting all the cases
- are they incident or prevalent
- is there something special about the cases
- is the time frame of the study relevant to disease/exposure
- was there a sufficient number of cases selected
- was there a power calculation

4. Were the controls selected in an acceptable way?

Yes ☐
Can't Tell ☐
No ☐

Comments:

HINT: We are looking for selection bias which might compromise the generalisability of the findings
- were the controls representative of the defined population (geographically and/or temporally)
- was there something special about the controls
- was the non-response high, could non-respondents be different in any way
- are they matched, population based or randomly selected
- was there a sufficient number of controls selected

CASP
Critical Appraisal Skills Programme

5. Was the exposure accurately measured to minimise bias?

Yes ☐
Can't Tell ☐
No ☐

HINT: We are looking for measurement, recall or classification bias
- was the exposure clearly defined and accurately measured
- did the authors use subjective or objective measurements
- do the measures truly reflect what they are supposed to measure (have they been validated)
- were the measurement methods similar in the cases and controls
- did the study incorporate blinding where feasible
- is the temporal relation correct (does the exposure of interest precede the outcome)

Comments:

6. (a) Aside from the experimental intervention, were the groups treated equally?

HINT: List the ones you think might be important, that the author may have missed
- genetic
- environmental
- socio-economic

List:

6. (b) Have the authors taken account of the potential confounding factors in the design and/or in their analysis?

Yes ☐
Can't Tell ☐
No ☐

HINT: Look for
- restriction in design, and techniques e.g. modelling, stratified-, regression-, or sensitivity analysis to correct, control or adjust for confounding factors

Comments:

CASP
Critical Appraisal Skills Programme

Section B: What are the results?

7. How large was the treatment effect?

HINT: Consider
- what are the bottom line results
- is the analysis appropriate to the design
- how strong is the association between exposure and outcome (look at the odds ratio)
- are the results adjusted for confounding, and might confounding still explain the association
- has adjustment made a big difference to the OR

Comments:

8. How precise was the estimate of the treatment effect?

HINT: Consider
- size of the p-value
- size of the confidence intervals
- have the authors considered all the important variables
- how was the effect of subjects refusing to participate evaluated

Comments:

CASP
Critical Appraisal Skills Programme

9. Do you believe the results?

Yes ☐
No ☐

HINT: Consider
- big effect is hard to ignore!
- Can it be due to chance, bias, or confounding
- are the design and methods of this study sufficiently flawed to make the results unreliable
- consider Bradford Hills criteria (e.g. time sequence, does-response gradient, strength, biological plausibility)

Comments:

Section C: Will the results help locally?

10. Can the results be applied to the local population?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider whether
- the subjects covered in the study could be sufficiently different from your population to cause concern
- your local setting is likely to differ much from that of the study
- can you quantify the local benefits and harms

Comments:

11. Do the results of this study fit with other available evidence?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- all the available evidence from RCT's Systematic Reviews, Cohort Studies, and Case Control Studies as well, for consistency

Comments:

Remember One observational study rarely provides sufficiently robust evidence to recommend changes to clinical practice or within health policy decision making. However, for certain questions observational studies provide the only evidence. Recommendations from observational studies are always stronger when supported by other evidence.

Appendix E (Randomized Controlled Trials)

CASP
Critical Appraisal Skills Programme

Paper for appraisal and reference:.....

Section A: Are the results of the trial valid?

1. Did the trial address a clearly focused issue?

Yes ☐
Can't Tell ☐
No ☐

HINT: An issue can be 'focused' in terms of
- the population studied
- the intervention given
- the comparator given
- the outcomes considered

Comments:

2. Was the assignment of patients to treatments randomised?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- how this was carried out
- was the allocation sequence concealed from researchers and patients

Comments:

3. Were all of the patients who entered the trial properly accounted for at its conclusion?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- was the trial stopped early
- were patients analysed in the groups to which they were randomised

Comments:

Is it worth continuing?

CASP
Critical Appraisal Skills Programme

4. Were patients, health workers and study personnel 'blind' to treatment?

Yes ☐
Can't Tell ☐
No ☐

Comments:

5. Were the groups similar at the start of the trial

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
• other factors that might affect the outcome, such as; age, sex, social class

Comments:

6. Aside from the experimental intervention, were the groups treated equally?

Yes ☐
Can't Tell ☐
No ☐

Comments:

Section B: What are the results?

CASP
Critical Appraisal Skills Programme

7. How large was the treatment effect?

HINT: Consider
- what outcomes were measured
- Is the primary outcome clearly specified
- what results were found for each outcome

Comments:

8. How precise was the estimate of the treatment effect?

HINT: Consider
- what are the confidence limits

Comments:

Section C: Will the results help locally?

9. Can the results be applied to the local population, or in your context?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider whether
- the patients covered by the trial are similar enough to the patients to whom you will apply this
- how they differ

Comments:

10. Were all clinically important outcomes considered?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider whether
- there is other information you would like to have seen
- if not, does this affect the decision

Comments:

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11. Are the benefits worth the harms and costs?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- even if this is not addressed by the trial, what do **you** think?

Comments: