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Return to Learn: A review of cognitive rest versus rehabilitation after sports concussion

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Abstract

BACKGROUND: Cognitive rest is the recommendation for all patients with acute sports concussion.

OBJECTIVE/METHODS: A comprehensive literature search was conducted for the research question “What is the optimal cognitive load for patients with a sports concussion?”

RESULTS: Seven studies met the inclusion criteria. The optimal cognitive load for patients after sports concussion is yet to be determined.

CONCLUSIONS: Additional controlled trials of cognitive rehabilitation are needed to establish best clinical practice. The authors suggest memory training, cognitive behavioral therapy, and environmental interventions as areas of future research for sports concussion injuries.

Keywords

Brain concussion; sports; brain injury; cognitive therapy; cognitive symptoms; rest

1. Introduction

Sports concussion is a type of traumatic brain injury, or TBI, caused by a bump, blow, or jolt to the head that can change the way the brain normally works (“Sports Concussion,” 2013). Sports concussion is a sub-type of traumatic brain injury (TBI), and distinct from other TBI’s in many ways. For example, most symptoms of sports concussions resolve spontaneously in 7–10 days (“Sports Concussion,” 2013). In contrast, other types of traumatic brain injuries may have prolonged or permanent symptoms that require active physical and cognitive rehabilitation (Bayley et al., 2014). Many sports concussions do not require structured rehabilitation to achieve full recovery. However, there may be a role for cognitive rehabilitation if spontaneous recovery does not occur. For this reason, it may be

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Conflict of interest

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useful to view injuries on a spectrum of effect on brain function whether or not they are resulted from sports participation or trauma or other cause. Treatment recommendations from other types of traumatic brain injuries on this spectrum may provide clues to help patients with sports concussion recover.

Currently, cognitive rest is the recommendation for all patients with acute sports concussion (McCrory et al., 2013; Purcell & Canadian Paediatric Society, 2012; “Sports Concussion,” 2013). Recently this recommendation has been questioned for being empirical, (Brolinson, 2014; Graham, Rivara, Ford, & Spicer, 2014; Kirkwood, Randolph, & Yeates, 2012; Silverberg & Iverson, 2013) ill-defined, and difficult for patients to comply with (Brolinson, 2014; Silverberg & Iverson, 2013). The recommendation is based on animal models (Griesbach, Hovda, Molteni, Wu, & Gomez-Pinilla, 2004) showing worsening pathology after unrestricted physical activity and on the widely accepted assumption that concussion symptoms worsen with increased cognitive load (Valentine & Logan, 2012).

A consensus definition of rest is avoidance of activities that require concentration or attention (McCrory et al., 2013). The Center for Disease Control recommends cognitive rest to last 24 to 48 hours, and then began a stepwise return to normal activity (“Sports Concussion,” 2013). Many clinicians recommend a stricter definition of rest for a prolonged duration (rest lasting until complete symptom resolution) (Brunk, 2014; Lee & Fine, 2010). A strict definition of rest includes no school, no homework or tests, no travel or shopping or trips outside of the home, no driving, no visits with friends or social visits in or outside of the home, increased sleep, significant reduction of television viewing and no watching athletic games or other visually intense movies, no video games, no computer usage, no texting, phone calls only if necessary, and no reading unless minor in nature (such as reading directions on a medication bottle).

Cognitive rest is not the recommendation for patients with non-sports concussion traumatic brain injuries (Cicerone et al., 2011). Current neurosciences research on neuroplasticity shows that both the normal developing brain and the injured brain are malleable. Behavioral experiences seem to be the most significant driver of this plasticity and can influence the brain in an adaptive fashion (Nudo, 2013). As such, active rehabilitation is the standard of care for patients with non-sports concussion traumatic brain injuries (Bayley et al., 2014). While active rehabilitation allows patients to rest, rest does not dominate the plan of care. Active rehabilitation is different from cognitive rest and involves engaging the patient in cognitive tasks usually with a multi-disciplinary group of care providers. This is essentially the opposite of cognitive rest, and may involve talking, reading, game playing, computer use and travel outside the home (Bayley et al., 2014; Cicerone et al., 2011).

Since the empirical recommendation that patients with sport concussion should have cognitive rest (McCrory et al., 2005) there has been additional research characterizing the optimal cognitive load for patients with a sports concussion. The aim for this paper is to review the literature on optimal cognitive load for patients with a sports concussion. Reaching this goal will help define the possible role of rehabilitation after sports concussion.

2. Methods

A comprehensive literature search was conducted for the research question, “What is the optimal type and amount of cognitive rest for patients with a sports concussion?” The following databases were used: PubMed, Scopus, CINAHL, Article First, Cochrane, and PsycINFO. The aim was to identify trials evaluating the effects of cognitive load on recovery from sports concussion. The terms *sports concussion*, *traumatic brain injury*, *brain concussion*, were combined with *cognitive rest*, *cognition*, *cognitive therapy*.

Titles of all studies captured by the search ($n = 701$) were reviewed. Inclusion criteria were as follows: (1) report of original research. Research from randomized controlled trials, cohort studies, quasi-experimental design, case series, case crossovers were included; (2) acquired brain injury including sports concussion; (3) cognitive load either decreased or increased load was a main focus of the article; (4) English language. Age was not a factor for inclusion; both pediatric and adult literature was searched and included. Exclusion criteria were: individual case presentations, studies with the main outcomes being biomarkers or imaging studies. Animal research, studies on pharmacological treatment, or studies of populations with non-traumatic brain injuries (e.g. Alzheimer’s disease, AIDS, cancer, post-traumatic stress disorder, and stroke) were also excluded. A panel of experts in the field of sports concussion and rehabilitation (see Acknowledgements) were asked to identify any additional relevant articles and the reference lists of prior review articles was reviewed to ensure completeness of the literature search. Figure 1 shows the research method algorithm. Research was graded using the Journal of Bone and Joint Surgery guidelines (“Instructions for Authors; Levels of Evidence,” 2015).

3. Results

The initial search identified 701 potential articles. The results of the search were reviewed by the expert panel that identified one additional article (Thomas, Apps, Hoffmann, McCrea, & Hammeke, 2015) for possible inclusion. It was agreed that this study met the inclusion criteria.

Seven studies met the inclusion criteria and are presented in Table 1. Six of the studies were designated Class IV and one study was designated Class I (Gronseth, Woodroffe, & Getchius, 2011). Class IV studies are defined as having a lack of control group, or not including patients with and without the disease (“Instructions for Authors; Levels of Evidence,” 2015). Absence of comparison groups creates a high risk of bias in these studies. Class I studies have randomized comparison groups and less risk of bias.

3.1. The role of cognitive rest

A class I study, which was a randomized controlled trial of 99 patients aged 11–22 years with a concussion showed no benefit of prolonged rest (Thomas et al., 2015). At discharge from the Emergency Department, one group was instructed to rest for 1–2 days then begin a stepwise return to activity. The second group was instructed on strict rest for 5 days. Participants tracked their physical and mental activities with daily diaries. Objective and subjective measures of concussion were obtained at day 3 and day 10 post injury. There

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were no differences in objective measures between the groups. However, the group assigned to strict rest reported longer symptom duration. It took 3 days longer for 50% of the patients in the strict rest group to recover. Additionally, this group reported a significantly higher total number of post-concussion symptoms with a higher trajectory of emotional symptoms. The authors concluded that one possibility is discharge instructions influenced the perception of illness, augmenting symptom reporting. Alternatively, prolonged rest isolates people from school, work and normal social activities and may promote perseveration on post-concussion symptoms. Another study provided corroborative findings. This observational study where 63% of the sample was recommended cognitive rest reported no association between rest and recovery (Gibson, Nigrovic, O'Brien, & Meehan, 2013). Gibson et al. found no link between cognitive rest and symptom resolution after adjusting for concussion severity. In this retrospective cohort of 184 athletes only initial concussion severity was associated with duration of symptoms.

One study showed improvement after being prescribed cognitive rest. This study lacked a comparison group, and therefore has a high risk of bias. The retrospective chart review of 49 young people (age range 14–23 years), all prescribed one week of cognitive rest regardless of time since injury (Moser, Glatts, & Schatz, 2012). Strict cognitive rest included “no school, no homework or tests, no travel or shopping or trips outside of the home, no driving, no visits with friends or social visits in or outside of the home, increased sleep, significant reduction of television viewing and no watching athletic games or other visually intense movies, no video games, no computer usage, no texting, phone calls only if necessary, no reading unless minor in nature (such as reading directions on a medication bottle), no chores, no physical exercise, no lifting weights, and no physical activity that results in perspiration.” Parents monitored and reported on compliance. All patients had improvement in ImPACT testing and improvement in symptoms after one week of cognitive and physical rest. This case series supports cognitive rest at all stages of recovery, acute, sub-acute and chronic. However, with no comparison group, it is impossible to know that the improvement was the result of prescribed rest. Another limitation is that the actual compliance with strict cognitive rest was not monitored, and the authors mentioned non-uniform compliance specifically to the 100% restrictions on computer and cell phone use. The authors also cautioned that there may be negative consequences (i.e. academic risk, social and emotional reactions), not evaluated in the study, of imposed rest with young people being sequestered away from school and team-mates.

3.2. Role of cognitive activity

Going to school may have a positive effect on recovery. One main difference between the two groups in the study by Thomas et al. was the presence or absence from school. The group that went to school reported less post-concussion symptoms at day 3 and day 10 (Thomas et al., 2015). A separate study by Majerske et al., retrospectively group patients into self-reported activity levels during the first 30 days post injury (Majerske et al., 2008). Objective and subjective measures showed a positive effect of school attendance. Patients who went to school performed better on each domain of ImPACT testing and reported less post-concussion symptoms than patients who did not go to school. This study supports recommending a moderate level of cognitive activity. When analyzing the activity groups,

the group who reported school attendance and high levels of physical activity (participation in sports games) performed worse than the patients who limited their physical activity to light home exercise. Two studies agree that a moderate level of cognitive activity, i.e. going to school, has a positive effect on recovery (Majerske et al., 2008; Thomas et al., 2015).

It is unclear if the highest levels of cognitive activity adversely affect recovery. The study by Thomas et al. showed no decrement in recovery in the group of patients with high cognitive activity. This included working on homework or studying, taking quizzes, tests or giving presentations (Thomas et al., 2015). However, a class IV study correlated longer recovery in patients performing higher levels of cognitive activity (doing more than one hour of homework, online activity, or video games per day) (Brown et al., 2014). Brown et al. followed a prospective cohort of 335 young people who were recruited from a concussion clinic and measured the duration of concussion symptoms (Brown et al., 2014). The mean duration of symptoms was 43 days. There were no objective measures of concussion. Patients with the highest levels of cognitive activity had prolonged symptoms. The conflicting results of these two studies may be explained by study design (randomized controlled trial vs. observational), by differing populations (ER presentation vs. days or weeks post injury), or follow up period (10 days vs. 500 days).

One study reported the immediate effect of a cognitive task on subjective symptoms after acute sports concussion (Covassin, Crutcher, & Wallace, 2013) and found some symptoms worsened and some symptoms improved. In this study, student athletes self-reported their symptoms using a standardized post-concussion scale, before and after performing a cognitive task. The cognitive task involved Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) testing, which is a computerized assessment of verbal memory, visual memory, motor speed processing, and reaction time. On day 3 after acute sports concussion, there were 8 symptoms that changed significantly after the cognitive task. Two out of 8 symptoms improved, and 6 out of 8 symptoms worsened. Similar symptoms were reported to change in opposite directions. For example, after the cognitive task, student athletes reported improved balance, but worsened dizziness. There were no objective measures of balance in this study. There was spontaneous resolution of most symptoms and at day 10 after sports concussion, only 3 symptoms changed significantly after the cognitive task. One out of 3 symptoms improved (less anxiousness) while 2 out of 3 symptoms worsened (greater sadness and difficulty remembering). Overall this study indicates that some concussion symptoms worsen after a repetitive computerized cognitive task of verbal and visual memory, processing speed and reaction. It was unclear what effect there may have been from errors in self-reporting.

A case series described a program of active rehabilitation for patients with chronic concussion symptoms (Gagnon, Galli, Friedman, Grilli, & Iverson, 2009). Sixteen children, with symptoms lasting more than 4 weeks after injury, were enrolled in a physical and mental activity based rehabilitation program. Post-concussion symptoms, return to physical activity and satisfaction were measured. Cognitive treatments included education promoting motivation to address attitude and behavior towards the injury, sports-related visualization exercises and imagery techniques. The aim was to improve confidence and self-efficacy towards recovery. The mean duration of the program was 4.4 weeks. Participants showed

significant and rapid improvement with the intervention and all participants returned to their normal lifestyle after completion of the program. This study suggests that an active rehabilitation intervention has a positive effect on recovery in children with chronic concussion symptoms. However, this conclusion is limited by the study design. However, it suggests safety of engaging in exercise and cognitive rehabilitation prior to being asymptomatic at rest among children with persistent symptoms.

4. Discussion

4.1. Optimal cognitive load for patients with a sports concussion

The optimal cognitive load for a patient after a sports concussion has not been defined in the current literature. Two studies suggest that the optimal cognitive load may depend on the time after injury. In the acute period (day 1 and day 2 post-injury) there is one class I study that supports 1–2 days of cognitive rest (Thomas et al., 2015). The sub-acute period (days 3–21 post injury) there is one class I study (Thomas et al., 2015) and one class IV study (Majerske et al., 2008) that agree school attendance is beneficial.

Cognitive rest recommendations are based partially on the assumption that symptoms of concussion worsen with increased cognitive load (Valentine & Logan, 2012). Limiting activity in the highest levels of cognitive activity may or may not be important for recovery. Evidence is conflicting. Two class IV studies support limiting high-level cognitive demands (Brown et al., 2014; Covassin et al., 2013), and one class I study does not support a limitation of cognitive activities (Thomas et al., 2015). High levels of cognitive activity was defined by one study as more than one hour of combined homework, videogames, or on-line activity, or unrestricted activity. During the chronic period post injury (>21 days) the optimal cognitive load is unknown, and evidence is lacking in this group.

There is no agreed upon definition of cognitive rest. However, a strict definition cognitive rest contains “no reading” and thus excludes educational materials that are shown to be beneficial. One study in sports concussion population shows that educational booklets in the acute period have a positive effect on recovery (Ponsford et al., 2001). The literature from populations with more severe traumatic brain injuries (TBI) agrees that early and continuing education minimize long term symptoms (Bell et al., 2005; Mittenberg, Tremont, Zielinski, Fichera, & Rayls, 1996; Ponsford et al., 2001). It is believed such education produces well-informed and sympathetic family members, friends, teachers and employers for the emotional and functional support necessary for optimal recovery.

4.2. Role of rehabilitation after sports concussion

The role for cognitive rehabilitation in the pathway of recovery has not been well studied. Benefit has yet to be established but may depend on time after injury. A majority of acute sports concussions resolve spontaneously, and cognitive rehabilitation may have little added benefit in the first few days. In the sub-acute period school attendance has been shown to be beneficial, but additional research is needed to determine if high-level cognitive functions prolong recovery. In the chronic period, data is conflicting. The quality of study design in the chronic period is class IV. Despite limited evidence, active cognitive rehabilitation in the

chronic phase of sports concussion has been recommended by the American Academy of Physical Medicine and Rehabilitation (Levy & Dixit, 2013) and others (Leddy, Sandhu, Sodhi, Baker, & Willer, 2012; Makdissi, Cantu, Johnston, McCrory, & Meeuwisse, 2013).

4.3. Limitations

Most of the studies presented here (6 out of 7) were observational studies or cohort studies/case series without comparison groups. This represents lower quality research that presents conflicting results on the effect of cognitive load on recovery. The one high quality design, a randomized controlled trial, followed patients for 10 days and therefore cannot be generalized beyond this time period. Age is a factor in recovery from sports concussion. The studies presented here all focused on a young athletic population. The evidence can be applied to ages as young as eight to twenty three years old.

4.4. Future directions for research

The literature on patients with other types of TBI may show future directions for research in the sports concussion population. Literature from the general TBI population shows that rest (defined as no mental or physical exertion) is an unsuccessful treatment in the acute period (de Kruijk, Leffers, Meerhoff, Rutten, & Twijnstra, 2002; Willer & Leddy, 2006). A randomized trial of patients with mild TBI showed that cognitive rest in the acute period had no effect on post-traumatic complaints at two and three weeks and six months post-concussion (de Kruijk et al., 2002). Early cognitive rehabilitation for TBI patients has been implemented into clinical practice ("Consensus conference. Rehabilitation of persons with traumatic brain injury. NIH Consensus Development Panel on Rehabilitation of Persons With Traumatic Brain Injury," 1999) and contrasts with sports concussion practice standards (McCrory et al., 2005).

TBI patients are sub-grouped according to their presenting symptoms and actively rehabilitated accordingly (Cicerone et al., 2011). Sub-grouping for cognitive rehabilitation needs to be studied in a sports concussion population. Cognitive therapy, in the TBI population, begins with assessments to identify the patient's strengths and weaknesses, and then applies various compensatory strategies and re-training techniques to improve cognition and psychological functioning (Tsaousides & Gordon, 2009). Treatment recommendations are modified to address presenting symptoms. For example, apathetic or vegetative patients are commonly treated in a stimulating environment with the lights on, such as an open room with other patients, staff, or visitors. Disinhibited impulsive patients are placed in quieter environments with less noise, distraction, or overwhelming stimulation (Wagner, Arenth, Kwasnica, & Rogers, 2010). Similar examples of environmental interventions are already being used clinically for sports concussion patients including rest breaks and additional time to complete tasks and assignments, tutoring, and note taking assistance. Future research could focus on which sub-groups of sports concussed patients benefit from special work areas that are either quieter or more lightly stimulating.

The goal of cognitive rehabilitation is to improve a person's functioning in all aspects of their family, work, school, and community life (Cicerone et al., 2011; "Consensus conference. Rehabilitation of persons with traumatic brain injury. NIH Consensus

Development Panel on Rehabilitation of Persons With Traumatic Brain Injury,” 1999; Levine et al., 2000; Ruff & Niemann, 1990; Waldron, Casserly, & O’Sullivan, 2013). Memory training is a particular cognitive exercise that has been well studied and is now a practice standard for patients with mild TBI (Cicerone et al., 2011). Cognitive behavioral therapy is another intervention with high quality evidence that shows a positive effect on recovery from TBI (Carnevale, Anselmi, Johnston, Busichio, & Walsh, 2006; Carney et al., 1999; Comper, Bisschop, Carnide, & Tricco, 2005; McDonald et al., 2008; Mittenberg et al., 1996; Silverberg et al., 2013; Tiersky et al., 2005). Such therapy may play an influential role in TBI recovery, because many of the symptoms of brain injury and sports concussion are classified as psychological, including being more emotional, irritable, sad, nervous or anxious (Silverberg et al., 2013). Applying these two cognitive interventions to sports concussion is another possible future direction for research.

Cognitive rehabilitation is the practice standard in all phases of recovery from TBI. (Bayley et al., 2014; Cicerone et al., 2011; “Consensus conference. Rehabilitation of persons with traumatic brain injury. NIH Consensus Development Panel on Rehabilitation of Persons With Traumatic Brain Injury,” 1999) and may serve as a guide for future research on sports concussion.

5. Conclusions

As presented here, the optimal cognitive load for patients after sports concussion has not been established in the literature. Additional controlled trials of cognitive rehabilitation are needed to establish best clinical practice in all phases of recovery after a sports-related concussion. The literature to date supports 1–2 days of cognitive rest followed by a step-wise return to activity. General TBI literature suggests that *active* cognitive rehabilitation using cognitive behavioral therapy or memory training should be considered for future sports concussion research. In addition, individualized environmental compensatory strategies needs to be studied in the sports concussed population.

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Fig. 1.
Methods of review.

Table 1

Studies evaluating the effects of cognitive demands on recovery from sports concussion

Reference	Study Design	Population	Sample Size	Treatment	Outcome Measures & Time of Measurement	Findings	Comments	Level of evidence evaluation and conclusions
Thomas et al., 2015	Randomized Controlled Trial	Acute concussion presented day 1 to Emergency Department, age 11 to 22 years	99	5 days of strict rest vs. 1–2 days of rest followed by a stepwise return to activity	Subjective measures Activity diaries, Post-concussion Symptom Scale Objective measures ImPACT test battery, paper neurocognitive battery, Balance Error Scoring System. Subjective measures reported daily. Objective measures taken at day 3 and day 10	The group assigned to 5 days of strict rest reported more post-concussion symptoms with slower symptom resolution, but had no differences on objective testing (ImPACT or other neurocognitive assessments, or balance measures)	Followed for 10 days post injury. Strict rest was defined as no school, work or physical activity. Population was mixed (70% sports concussion, 15% fall, 7% motor vehicle collision, and other 8%	Class I In support of 1–2 days of cognitive rest. Extended rest has no additional benefit and may have harm.
Covassin et al., 2013	Cross-sectional	Acute sports concussion, presented to clinic by day 3, age range not given but population was high school and collegiate athletes	165	Interventional	Post-concussion scale before and after a computerized cognitive task (the ImPACT test battery). Measured day 3 and day 10.	At day 3 there were 8 post-concussion symptoms that showed significant changes after the cognitive task. 2/8 symptoms improved after the cognitive task. 6/8 symptoms worsened. At day 10 there were 3 symptoms that showed significant changes after the cognitive task. 1/3 symptoms improved after the cognitive task, 2/3 symptoms worsened after the cognitive task.	There was no objective measure of reported symptoms.	Class IV. In support of limiting computerized cognitive tasks.
Majerske et al., 2008	Retrospective cohort	Acute sports concussion presented to clinic (time frame of concussion not specified), age 13–18 years	95	Observational	Post-concussion scale; ImPACT. Measured at 5 time points during the first 30 days.	Patients who went to school had better outcomes than not going to school. Poor outcomes were seen in the group that combined school with high levels of physical activity.	Physical activity was the main focus of the study. Cognitive activity was measured by school attendance	Class IV In support of moderate levels of cognitive activity.
Brown et al., 2014	Prospective cohort	Acute and sub-acute sports concussion presented to clinic <21 days from onset of injury, age 8–23 years	335	Observational	Duration of post-concussion symptoms. The patients were followed until symptom resolution (as long as 500 days for a small number of patients)	Patients in the highest quartile of cognitive activity reported longer duration of post-concussion symptoms.	A graded time based scale quantified self-reported cognitive load. Although school attendance was not reported.	Class IV In support of limiting the highest level of cognitive activity.
Gibson et al., 2013	Retrospective cohort	Acute to chronic sports concussion presented to clinic, age 8–26 years	135	Observational	Duration of post-concussion symptoms, balance error symptom score, neurocognitive	No link between cognitive rest and symptom resolution after adjusting for concussion severity.	Compliance with cognitive rest was not monitored	Class IV Refutes that cognitive rest is associated with positive outcomes.

Reference	Study Design	Population	Sample Size	Treatment	Outcome Measures & Time of Measurement	Findings	Comments	Level of evidence evaluation and conclusions
Moser et al., 2012	Retrospective case series	Acute to chronic sports concussion presented to clinic, age 14–23 years	49	At least 1 week of cognitive rest	tests. The patients were followed until symptom resolution (time frame not reported) Post-concussion scale; ImPACT The patients were followed until symptom resolution (time frame not reported)	A decrease in symptoms and improvement in cognitive performance was seen in all patients after one week of cognitive rest.	The study combined physical and cognitive rest. Compliance with strict cognitive rest was not monitored	Class IV In support of cognitive rest at all stages of recovery (acute to chronic).
Gagnon et al., 2009	Prospective case series qualitative	Chronic sports concussion (>4 weeks of symptoms), presented to tertiary care hospital based pediatric clinic, age 10–17 years	16	Active rehabilitation with visualization for cognitive exercise combined with physical exercises	Post-concussion symptoms, return to physical activity, parent/patient satisfaction. The patients were followed weekly until symptom resolution (as long as 12 weeks)	All patients returned to their normal lifestyle.	The study combined physical and cognitive activity. Type of education, behavior and attitude “normalization” was not specified. Compliance with visualization exercises was not reported	Class IV In support of cognitive rehab in the chronically symptomatic pediatric population.