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ORIGINAL ARTICLE

Examining prescribed rest as treatment for adolescents who are slow to recover from concussion

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Abstract

Objective: Rest is a widely recommended treatment for concussion, but its utility is unclear following the acute stage of recovery. This study examined the effects of 1-week of prescribed rest in concussed adolescent athletes.
Method: Participants were 13 adolescent athletes with persistent symptoms following a concussion. More than three-quarters (77%) had self-reported ADHD, learning disability or two prior concussions. All completed ImPACT® at another facility, but none completed a period of comprehensive rest prior to examination at a specialty practice. Three time points of test data were compared, to control for possible spontaneous recovery: Test 1 (external facility), Test 2 (before prescribed rest) and Test 3 (following prescribed rest).
Results: Repeated measures ANOVAs revealed a significant effect of prescribed rest on all ImPACT® composite scores and the total symptom score. Post-hoc analyses revealed no significant differences between Time 1 and Time 2, whereas significant differences were present after prescribed rest. Following prescribed rest, having two or more reliably improved cognitive test scores *or* having improved symptoms was present in eight of the 13 patients (61.5%).
Conclusions: A substantial percentage of adolescents with persistent symptoms following concussion showed improvement in symptoms and cognitive functioning following education, reassurance and 1-week of prescribed rest.

Keywords

Concussion, baseline testing, comprehensive rest, concussion management

History

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Introduction

The primary treatment for sport-related concussion is rest. It is widely recommended that athletes rest until they are asymptomatic, and then follow a stepwise progression of activity culminating in medical clearance and return to sport [1, 2]. It is logical to recommend rest, especially in the first few days following injury, because the injured brain is believed to be in a state of neurometabolic crisis [3, 4]; rest might, theoretically, facilitate neurometabolic recovery; and a rest period reduces the likelihood of an athlete sustaining another injury during this recovery period. There is some evidence in the animal literature that mild injuries to the brain, in close temporal proximity, result in magnified pathophysiology [5–7]. There is also evidence in the animal literature that vigorous exercise in the first few days following brain injury suppresses neuromolecular markers of neurogenesis and neuroplasticity [8–11]. Therefore, it is not surprising that reviews [12], consensus statements [2, 13] and agreement statements [14, 15] recommend an initial period of rest.

There are some observational studies suggesting that having higher levels of physical and cognitive activity during the acute recovery period is associated with greater post-acute symptom reporting in concussed athletes [16, 17]. To the authors' knowledge, however, there are only two published studies on prescribed rest in the world literature. One was a randomized controlled clinical trial with civilians recruited from the emergency department [18] and one was an uncontrolled study of youth athletes seen in a specialty clinic [19]. In the randomized trial [18], those patients who engaged in 6 days of bed rest did not have clearly better outcomes at 2 weeks, 3 months or 6 months following injury compared to patients who were not prescribed bed rest. Moser et al. [19] reported results from an uncontrolled observational treatment study in which 49 youth athletes were tested before and after being prescribed 1 week of rest (not bed rest). In that study, 'rest' was defined as a period of ~1 week of abstinence from exercise, school attendance, homework, reading, computer usage, telephones, texting, videos, television, trips outside of the home and social visits in the home. Participants showed significantly improved performance on ImPACT® and

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decreased symptom reporting following prescribed cognitive and physical rest ($p < 0.001$, partial eta-squared ranged from 0.14–0.52). These athletes appeared to benefit from cognitive and physical rest, whether applied early or late in the course of recovery from concussion. Notably, improvements in cognitive and physical symptoms occurred even when rest was prescribed weeks or months post-injury [19]. The study had no control group, however, to address practice effects, placebo effects, or spontaneous symptom changes. Moreover, there was only a single follow-up period for those athletes, so the number who had sustained improvement, recovery and return to their normal lives is unknown.

The present study replicates and extends the study by Moser et al. [19], while attempting to control for possible spontaneous recovery. It identified youth athletes who (i) were diagnosed at their school or another facility as having sustained a concussion and they had undergone post-concussion testing there, (ii) were not encouraged to rest following their injury or were noncompliant and did not rest and (iii) were later referred for clinical assessment and treatment due to persistent symptoms. It was hypothesized that athletes would show significant improvement on neurocognitive testing and ratings of concussion-related symptoms after engaging in a week of comprehensive rest, even when rest was prescribed after the acute (e.g. 7–10 day) period of recovery.

Methods

Participants

Participants were 13 adolescent athletes who were treated at a specialty clinic between 2010 and early 2013. A review of all youth concussion patients between ages 12–23 seen at the clinic revealed a total of only 13 cases that fit the following criteria exactly: (i) testing with ImPACT® was completed within a time period of 1 month after sustaining a concussion but prior to referral to the specialty clinic; (ii) the youth must not have engaged in a period of comprehensive rest prior to attending the specialty clinic; (iii) a second testing with ImPACT® must have been completed at the time of the initial appointment at the clinic and before a period of rest; (iv) the youth must have complied with a period of prescribed comprehensive rest after the second ImPACT® testing; and (v) the youth must have returned to clinic for a follow-up appointment (third testing on ImPACT®) after the period of rest. The sample was 57% male and their average age was 15.1 years (SD = 1.5; Range = 12–17). They sustained their injuries in a variety of sports (e.g. basketball, football, ice hockey, lacrosse, soccer, snowboarding). The prevalence of an attention deficit/or learning disorder was 46% and 77% of athletes had a history of prior concussions (31% with one previous concussion, 46% with two or more previous). Of the 13 adolescents, 10 (77%) had a self-reported diagnosis of ADHD or learning disorder *or* a history of two prior concussions. Thus, there was an over-representation of developmental problems and history of prior concussions in this sample.

ImPACT®

ImPACT® (Immediate Post-Concussion Assessment and Cognitive Testing) is a brief computer-administered neuropsychological test battery that consists of six individual test modules that measure aspects of cognitive functioning including attention, memory, reaction time and processing speed. Each test module may contribute scores to multiple composite scores. The *Verbal Memory* composite score represents the average percentage correct for a word recognition paradigm, a symbol number match task and a letter memory task with an accompanying interference task. These tests are conceptually similar to traditional verbal learning (word list) tasks and the auditory consonant trigrams test (i.e. the Brown-Peterson short-term memory paradigm), although the information is presented visually on the computer, not auditorily by an examiner. The *Visual Memory* composite score is comprised of the average percentage correct scores for two tasks; a recognition memory task that requires the discrimination of a series of abstract line drawings and a memory task that requires the identification of a series of illuminated X's or O's after an intervening task (mouse clicking a number sequence from 25 to 1). The first test assesses immediate and delayed memory for visual designs and the second test measures short-term spatial memory (with an interference task). The *Reaction Time* composite score represents the average response time (in milliseconds) on a choice reaction time, a go/no-go task and the previously mentioned symbol match task (which is similar to a traditional digit symbol task). The *Processing Speed* composite represents the weighted average of three tasks that are done as interference tasks for the memory paradigms. The *Impulse Control* composite score represents the total number of errors of omission or commission on the go/no-go test and the choice reaction time test. In addition to the cognitive measures, ImPACT also contains a Post-Concussion Symptom Scale that consists of 22 commonly reported symptoms (e.g. headache, dizziness, 'fogginess'). The dependent measure is the total score derived from this 22-item scale.

Procedures

All participants completed the online version of ImPACT® prior to coming to the specialty clinic and again at the clinic. At the time of the initial evaluation at the clinic, a list of cognitive and physical activities to be avoided was provided to the parents of athletes to help monitor rest compliance. The activities to avoid were explained to both athletes and parents. The list included: attending school, taking tests, taking notes, doing homework, doing general household chores, traveling (e.g. vacations), driving, trips outside of the home, social visits in home, visually watching TV, video games, computer use, phone use, reading, playing a musical instrument, drawing/artwork, aerobic exercise and lifting weights. Low exertion activities were recommended such as: listening to relaxing audiobooks, listening to relaxing music, listening to low volume non-stressful TV, folding laundry, setting the table, taking a slow walk outside in the yard, eating lunch outside at home, meditating, sleeping, receiving a manicure/pedicure/massage from a family member, listening to an older family member tell stories about the family history, taking a relaxing bath and brushing the pet dog. Athletes were advised to avoid activities that might produce a sweat or exacerbate symptoms.

Institutional review board approval was obtained for retrospective analysis of de-identified data. Assent and/or informed consent were obtained from athletes and parents.

Analyses

Repeated measures ANOVAs were conducted, with Time (Time 1: post-concussion, school or external facility, pre-specialty clinic; Time 2: post-concussion, before rest, at specialty clinic; Time 3: after 1 week of prescribed rest, at specialty clinic) as the independent variable and the four ImPACT® cognitive composite scores (verbal memory, visual memory, visual motor speed, reaction time) and total symptom scores as the dependent variables. Following Bonferonni correction for multiple comparisons, the adjusted alpha level required for statistical significance was $p < .01$. Partial-eta squared (η^2) and Cohen's d were calculated as measures of effect size. In addition, individual analyses for each subject were conducted using the reliable change methodology. This methodology is commonly used in clinical neuropsychology [20–24] and sports neuropsychology [25–27]. It provides an estimate of measurement error surrounding test–re-test difference scores by creating confidence intervals for these difference scores. Specifically, the standard error of the difference is used to create a confidence interval for the test–re-test difference score.

Results

The mean time between concussion and the Time 1 ImPACT® assessment was 9.9 days (SD = 10.1; Range = 1–34) and the mean time between the Time 1 assessment and the first clinic assessment (Time 2) was 24.8 days (SD = 30.7 days; Range = 2–103). The mean time between the pre- and post-rest assessments (Time 3) was 11.6 days (SD = 7.7 days; Range = 8–29). The number of days from injury to return to school was as follows: $M = 26.4$; Md = 29; SD = 12.1; IQR = 12–40; Range = 9–41. The number of days from first visit to the specialty clinic and return to school was as follows: $M = 15.2$; Md = 8; SD = 10.6; IQR = 7–29; Range = 7–30. The number of days from first visit to the specialty clinic and being deemed ready for exertion testing was as follows: M = 42.2; Md = 28; SD = 33.1; IQR = 14–61; Range = 5–115. Of the 13 cases, four voiced some resistance to the prescription of rest (three students and one parent, identified through a retrospective chart review). Ten of the students were documented as fully recovered by the time of their last visit or phone contact (the recovery status of the other three is unknown).

Repeated measures ANOVAs revealed a significant effect of rest on ImPACT® composite scores and total symptom scores. Planned post-hoc Tukey comparisons revealed no significant differences between pre-clinic (Time 1) and pre-rest assessments (Time 2), but there were significant differences between pre-rest (Time 2) and post-rest (Time 3) assessment data on all four ImPACT® composite scores and the Total Symptom Score (see Table I).

Individual test scores and reliable change analyses are presented in Table II. As seen in Table II, symptoms improved following rest in seven out of 13 patients (53.8%). However, four patients endorsed minimal or no symptoms on the Post-Concussion Scale (PCS) prior to being prescribed rest (PCS Total scores of 0–3; despite being referred for evaluation and treatment because they were still symptomatic). Symptoms improved in seven out of eight patients (87.5%) who had elevated PCS total scores before being prescribed rest. Only one patient (#7) who was symptomatic did not show improvement in symptoms following prescribed rest. Ten out of 13 (76.9%) patients showed statistically reliable improvement on one or more cognitive domain scores following prescribed rest. Four out of 13 (30.8%) showed reliable improvements on two or more cognitive domain scores. Importantly, it is extremely rare for healthy, uninjured athletes who are tested twice over a 1-month or a 1-year interval to obtain two or more statistically reliably improved test scores (i.e. this is present in only 0–1.4% of uninjured athletes [28]). If having two or more reliably improved cognitive test scores *or* improved symptoms is the criterion for improvement, than eight of the 13 patients (61.5%) had evidence of improvement following prescribed rest.

Discussion

Rest is a cornerstone of concussion management [1, 2], although there are ambiguities and problems with the recommendation for rest, such as how to define rest and how long to rest. In the present study, the student athletes were symptomatic following their concussions, they had not engaged in a period of comprehensive rest and they were referred to a specialty clinic for evaluation and treatment recommendations. It is important to note that bed rest was *not* prescribed and athletes were *not* encouraged to spend time in

Table I. Cognitive and symptom data across three post-injury time periods.

							Cohen's d		
Variable	Time 1	Time 2	Time 3	$F(2, 11)$	Sig.	Partial Eta^2	T1–T2	T2–T3	T1–T3
Verbal Memory	74.4 (11.8)	78.9 (11.9)	85.5 (9.1)	9.8	0.004	0.64	0.38	0.63	1.1
Visual Memory	62.0 (17.6)	66.2 (13.9)	76.9 (15.0)	12.4	0.002	0.69	0.27	0.74	0.91
Reaction Time	0.74 (0.15)	0.65 (0.12)	0.60 (0.09)	8.6	0.006	0.61	0.42	0.51	0.98
Motor Speed	32.9 (6.2)	35.6 (6.7)	38.8 (5.8)	6.0	0.017	0.52	0.67	0.48	1.2
Total Symptoms	23.9 (16.8)	19.6 (20.7)	6.5 (8.5)	5.7	0.02	0.51	0.23	0.90	1.4

Time 1 (T1): Post-concussion, pre-clinic; Time 2 (T2): pre-rest; Time 3 (T3): post-rest.
Verbal Memory, Visual Memory and Motor Speed: Time 3 scores > (i.e. improved) compared to Time 1 and Time 2; Reaction Time, Total Symptoms: Time 3 < (i.e. improved) compared to Time 1 and Time 2.

Table II. Examining symptom ratings, number of low cognitive test scores and number of reliably improved test scores by athlete.

	First post-injury assessment (Time 1)					Second post-injury assessment (Time 2)					After prescribed rest (Time 3)						Number of reliably improved scores	
			Number of low cognitive test scores					Number of low cognitive test scores					Number of low cognitive test scores					
Patient	Days post	PCS total	<25th %ile	<16th %ile	<10th %ile	Days post	PCS total	<25th %ile	<16th %ile	<10th %ile	Days post	PCS total	<25th %ile	<16th %ile	<10th %ile	Symptoms improved T2–T3	T1–T2	T2–T3
1	0	12	1	1	1	103	3	1	1	0	132	2	0	0	0	No	1	2
2	1	13	1	1	0	29	1	0	0	0	57	0	1	0	0	No	1	1
3	2	30	4	3	2	6	8	0	0	0	13	0	0	0	0	Yes	2	1
4	3	38	3	0	0	18	53	2	1	0	26	27	0	0	0	Yes	1	2
5	4	22	3	3	3	6	19	3	3	3	14	3	0	0	0	Yes	0	2
6	4	18	3	3	0	10	6	2	1	0	18	0	1	0	0	Yes	1	1
7	6	11	0	0	0	46	16	0	0	0	52	16	0	0	0	No	0	0
8	9	19	3	2	2	18	0	1	1	1	26	0	0	0	0	No	3	1
9	11	66	3	3	2	17	48	3	3	3	25	3	3	3	2	Yes	1	1
10	12	26	4	4	4	14	27	3	3	2	23	17	1	1	1	Yes	2	1
11	21	41	4	1	1	52	58	3	3	3	60	5	0	0	0	Yes	0	3
12	22	13	0	0	0	28	14	0	0	0	42	10	0	0	0	No	1	0
13	34	2	4	4	4	104	2	1	0	0	114	2	1	1	1	No	4	0

a dark room or to be seriously socially isolated. Student athletes were, however, encouraged to engage in comprehensive rest, which represented a major change in their lifestyle (i.e. stay home from school and avoid exercise and mentally/physically stimulating activities for 1 week). Symptoms improved following rest in 54% overall and in 87% of those who had elevated Post-Concussion Scale total scores before being prescribed rest. Most patients (i.e. 77%) showed statistically reliable improvement on one or more cognitive domain scores and four (31%) showed reliable improvements on two or more cognitive domain scores. If having two or more reliably improved cognitive test scores or improved symptoms is the criterion for improvement, than 61% had evidence of improvement following prescribed rest.

Following a period of rest, some of the effect sizes based on mean neurocognitive test scores reflected greater improvement following rest than during the pre-rest period (Table I, T1–T2 vs. T2–T3). In this regard, effect sizes reflected overall improvement from the time of referral to post-rest (T1–T3). Of note, some of the athletes in the sample self-reported low-to-normal symptom scores, while their neurocognitive test scores were somewhat low. It is not uncommon for athletes to deny symptoms [29], and recovery of cognitive function may follow clinical symptom recovery [30, 31]. Given that athletes in the current study were referred to the specialty clinic due to subjective complaints of not feeling 'fully recovered', low symptom scores may have occurred due to lack of awareness of the breadth and nature of the symptoms or subjective perception that a lone, predominating symptom was their primary problem.

The mechanisms by which prescribed rest might have facilitated improvement in symptoms and cognition in this sample of adolescent athletes who were slow to recover from concussion are unknown. It is essential to appreciate that nearly half the sample had a neurodevelopmental problem such as ADHD or learning disability and half reported a history of two prior concussions (combined, 77% had a pre-existing diagnosis *or* history of two concussions). As such, this sample had an over-representation of risk or complicating factors for concussion recovery [2, 13]. The extent to which these findings might generalize to adolescent athletes without these pre-injury risk factors is unknown. Extrapolating from the literature on mild traumatic brain injury (i.e. effects of education and reassurance) and mental health treatment studies, some factors that might be related to this improvement include (i) education and reassurance provided at the specialty clinic, (ii) non-specific treatment effects (clinician effects, other unmeasured effects) and (iii) placebo effects. Given that many adolescents and young adults have stressful and pressured daily lives, it is suspected that being completely 'unplugged' from all their activities (and much of their stressors) for a few days and getting much more sleep and rest than usual, at least in part, drove the improvements. In addition, being optimistic that rest would improve their condition may have been another factor in improvement (although it is not uncommon for adolescents to be initially doubtful and resistant to foregoing school and friends for a week). The extent to which improvement associated with rest could be directly linked to physiology is unclear. It is worth noting, however, that changes in the microstructure of white matter [32], neurometabolites [33] and cerebral blood flow [34] have been detected in athletes well beyond 10 days following injury.

This single-group, non-randomized treatment study has significant methodological limitations. The sample size was small and there was no control group (although this study could also be conceptualized as multiple replications of a single-subject research design, based on the individualized analyses provided in Table II). Because the participants were drawn from one treatment center, there may be a sample or self-selection bias that should be considered when interpreting these results. In addition, athletes completed their initial, post-concussion evaluation at an external facility, at which the test conditions and administrators were not documented. Their subsequent pre- and post-rest assessments were conducted at a different facility and were closely supervised in individual, quiet rooms. Research has shown that environmental conditions can affect test performance [35–37]; this factor was not controlled. This study does not tell us about the prevalence of concussed youth who may have recovered without rest and did not seek medical follow-up. Indeed, much more research is needed on rest following concussion. It is extremely difficult to conduct randomized clinical trials on this topic because (i) rest is standard treatment following sport-related concussion (thus, encouraging normal activities levels run counter to standard treatment), (ii) most athletes recover relatively quickly without complications (e.g. in less than 1 month) and (iii) it is difficult to predict who will be in the minority and have persistent symptoms beyond 1 month.

There are many unanswered questions relating to rest following concussion, such as:

(i) What is the definition of comprehensive cognitive and physical rest?
(ii) What activities should be encouraged and contraindicated during recovery?
(iii) For how long should one rest?
(iv) Are there specific symptoms that might benefit more (e.g. headaches, fatigue and sleep disturbance) or less (e.g. sadness) from a period of rest?
(v) Are there psychological factors or healthcare professional variables (positive or iatrogenic) that affect the recovery process?
(vi) Do person-specific variables, such as age, gender, presence of an attention or learning disorder, mediate or moderate the effects of rest?

In conclusion, a substantial percentage of adolescent athletes with persistent symptoms following concussion showed improvement in symptoms and cognitive functioning following education, reassurance and 1-week of prescribed rest. It is not known whether 3–4 days of rest, for example, might also be associated with similar improvements. Extracting the student athlete from the stresses and strains of his or her daily life and encouraging extra sleep may decrease symptoms and allow the clinician to better understand the nature and extent of the persisting complaints. Following a brief period of rest, the clinician can then determine what other specific treatment and rehabilitation strategies, if any, might be most useful. Clinicians are encouraged to work carefully with the student athlete to create a well-paced return to learn, return to play and return to life treatment plan that includes reassurance, positive expectations of recovery, reasonable re-introduction to activity and consideration of other physical and psychosocial factors that may affect outcome.

Declaration of Interest

Data were collected at the Sports Concussion Center of New Jersey (SCCNJ). Dr Rosemarie Moser is the owner of SCCNJ and some of the authors are employees or consultants at the Center. There were no other study sponsors. In the past, Dr Moser has served as a consultant to the International Brain Research Foundation, ImPACT Applications, Inc. and Pearson. These organizations had no role in the conceptualization or content of the current manuscript or the decision to submit for publication. In addition, she receives royalties from a book on youth concussion and special journal issue on mild traumatic brain injury. Philip Schatz, PhD, is a consultant to the Sports Concussion Center of New Jersey. He has also served as a consultant to the International Brain Research Foundation and to ImPACT Applications, Inc. to study the effects of concussion in high school and collegiate athletes. However, the latter two entities had no role in the conceptualization or content of the current manuscript or the decision to submit for publication. Grant Iverson, PhD has been reimbursed by the government, professional scientific bodies and commercial organizations for discussing or presenting research relating to mild TBI and sport-related concussion at meetings, scientific conferences and symposiums. He has a clinical and consulting practice in forensic neuropsychology involving individuals who have sustained mild TBIs (including professional athletes). He has received research funding from several test publishing companies, including ImPACT Applications, Inc., CNS Vital Signs and Psychological Assessment Resources (PAR, Inc.). He has not received research support from ImPACT Applications, Inc. in the past 3 years. He receives royalties from two books relating to neuropsychology and one test (WCST-64).

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