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Human Kinetics
CRITICALLY APPRAISED TOPIC

The Effects of Early Physical Activity Compared to Early Physical Rest on Concussion Symptoms

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Clinical Scenario: Currently, rest following concussion serves as the keystone of concussion treatment, but substantial evidence to support it is lacking. Recent literature suggests that early physical activity may be beneficial in reducing concussion symptoms which may influence clinical recovery time. ***Clinical Question:*** Does early physical activity decrease postconcussion symptoms compared to physical rest following concussion? ***Summary of Key Findings:*** A total of 5 articles were included that examined symptom duration changes at multiple time points. All 5 studies utilized follow-up time points compared to initial examination, but there was variance in the specific time points reported. Two studies employed control groups and compared strict or recommended rest to early activity or limited rest. Three studies were observational studies that directly compared baseline measurements to follow-up assessments. ***Clinical Bottom Line:*** Current evidence suggests that early physical activity in the acute phase following a concussion may decrease the time needed for symptom resolution compared to immediate rest. ***Strength of Recommendation:*** Using Centre for Evidence-Based Medicine 2011 level 3 evidence and higher, the results suggest that early physical activity during the acute phase of a concussion may decrease symptom duration; however, a lack of high-quality studies and inconsistent interventions are limitations to this recommendation.

Keywords: traumatic brain injury, rehabilitation, recovery, return to play, brain concussion

Clinical Scenario

Athletes diagnosed with sports-related concussion (SRC) have varied and complex clinical presentations that may result in symptoms that may hamper the professional, academic, or family life of athletes. An individualized approach to manage each athlete's unique symptom phenotype is necessary to prevent a protracted recovery.[1] For the past several decades, physical rest has been prescribed as a mainstay for SRC management.[1] More recently, rest has been divided into cognitive and physical components. Cognitive rest may include restricting daily living activities, such as school attendance, that may aggravate the symptoms.[1] Physical rest recommendations consist of refraining from physical activity until the postconcussive symptoms have subsided, followed by progressive restoration of physical activity as long as the athlete is asymptomatic.[1,2] Despite the widespread practice of prescribing rest following SRC, there remains a paucity of evidence supporting rest as an effective intervention. Emerging literature has indicated that prolonged periods of physical rest may be detrimental to SRC symptom recovery.[3,4] Physical activity during the subacute phase (≥6 wk following diagnosis) has been explored as a potential intervention to facilitate physical and psychological recovery from SRC as well as to improve academic outcomes in young athletes experiencing prolonged recovery.[5] Although several governing bodies[1,2] have recommended cognitive and physical rest following SRC, it is imperative for researchers to investigate viable postconcussion treatment strategies to appropriately manage symptoms and facilitate positive outcomes following SRC in the acute phase.

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Focused Clinical Question

Does early physical activity decrease postconcussion symptoms compared to physical rest following concussion?

Summary of Search, "Best Evidence" Appraised, and Key Findings

- An exhaustive literature search was conducted looking for original research meeting the established inclusion criteria using the search strategy described later. The initial literature search returned 836 possible studies—650 possible studies once duplicates were removed. All 650 studies were screened by all authors based off title for relativity, with 88 studies showing relevance. All 88 abstracts were assessed for inclusion eligibility, with 16 studies undergoing full article review.
- Of the 16 studies, only 5 studies met the inclusion criteria: 2 randomized control trials,[6,7] 2 prospective cohort studies,[8,9] and 1 retrospective cohort study.[10]
- All 5 studies employed a postconcussion symptoms assessment. Four studies[6–8,10] included symptom inventories with a Likert scale to indicate severity of each symptom, which included the postconcussion symptom scale, postconcussion symptom inventory, and graded symptom checklist. One study[6] used a 16-question posttraumatic complaint scale utilizing a standard visual analog scale for each question.
- Two studies utilized control groups and compared strict or recommended rest to early activity or limited rest.[6,7]
- Three studies were observational studies that directly compared baseline measurements to follow-up assessments.[8–10]
- All 5 studies used follow-up time points compared to initial examination, but there was great variation in the specific time points reported. Four studies[7–10] followed up within 7 days, all

5 studies followed up within the first month, and 1 study[6] followed out to 6 months postinjury.

Clinical Bottom Line

The current literature suggests that early physical activity in the acute phase (0–7 d) following a concussion may decrease the time needed for symptom resolution compared to strict rest.

Strength of Recommendation

Using the 2011 Oxford *Centre for Evidence-Based Medicine* taxonomy, level 3 evidence supports the recommendation that early physical activity during the acute phase of a concussion is associated with decreased symptom severity and duration. A lack of high-quality studies and inconsistent interventions limits this recommendation.

Search Strategy

Terms Used to Guide Search Strategy

- **P**atient group: concussed population
- **I**ntervention: early physical activity (acute phase of concussion)
- **C**omparison: physical rest
- **O**utcomes: symptom severity and duration, time to symptom resolution, and return to play

Sources of Evidence Searched (Databases)

- PubMed
- CINAHL
- Web of Science
- Google Scholar

Search Terms

A comprehensive search term was created to capture all articles potentially related to concussion recovery involving early physical activity and rest: (mtbi OR mild traumatic brain injury OR brain concussion OR cerebral concussion OR mild concussion OR moderate concussion OR severe concussion OR cerebral trauma OR minor head trauma OR mild head injury OR SRC OR src OR closed head injury) AND (exercise OR physical exercise OR treadmill OR bicycling OR biking OR cardio* OR aerobic activity OR walking OR buffalo concussion treadmill test OR BCTT OR controlled exercise OR graded exercise OR gradual intensity exercise OR gradual exercise OR physical exertion OR exercise therapy OR rehab* OR exertion) AND (cognitive recovery OR recovery OR rest OR mental recovery OR brain recovery OR brain rest OR physical rest) AND (symptom assessment OR symptom* OR self-reported symptom* OR head* OR dizz* OR confus* OR amnesia OR loss of consciousness OR nausea OR balance OR fatigue OR drowsiness OR sleep OR concentrat* OR fog OR slowed down OR light sensitivity OR sad* OR vomiting OR noise sensitivity OR nervous* OR memory OR numb* OR tingling OR irritable OR depress* OR vision)

Limits Used

- English language
- Original research
- Peer-reviewed academic journals
- Human population
- Published between 2000 and February 2017

Inclusion and Exclusion Criteria

Inclusion Criteria

- Comparison of physical activity to physical rest
- Comparison of strict physical rest to unrestricted physical rest
- Intervention occurred during the acute (0–7 d) phase postconcussion

Exclusion Criteria

- Failure to meet inclusion criteria and limits used

Results of Search

A total of 5 relevant studies were located and categorized as shown in Table 1 (based on Levels of Evidence, Centre for Evidence-Based Medicine, 2011). All 3 authors searched the available literature, analyzed articles for inclusion, and graded each included article using the PEDro scale. Consensus was reached upon all PEDro scoring among the 3 authors.

Best Evidence

The included studies (Table 2) were identified as the only available evidence examining early physical activity following a concussion that met our inclusion and exclusion criteria and thus serve as the best evidence.

Table 1 Summary of Study Designs of Articles Retrieved

Study design/methodology of articles retrieved	CEBM 2011 level of evidence	Number located	Authors
Randomized control trial	Level 2	2	de Kruijk et al[6] Thomas et al[7]
Prospective cohort study	Level 3	2	Grool et al[8] Buckley et al[9]
Retrospective cohort study	Level 3	1	Majerske et al[10]

CEBM, Centre for Evidence-Based Medicine.

Table 2 Characteristics of Included Studies

	Study 1 (Majerske et al[10])	Study 2 (Grool et al[8])	Study 3 (de Kruijk et al[6])	Study 4 (Thomas et al[7])	Study 5 (Buckley et al[9])
Study design	Retrospective cohort study (observational)	Prospective cohort study (observational)	Randomized control trial	Randomized control trial	Prospective cohort study (observational)
Participants	95 student athletes (80 males and 15 females: age = 15.88 [1.35] y) were assigned retrospectively to 1 of 5 groups based on postinjury activity intensity scale. Patient records had the patient's current academic status, information pertaining to postinjury activity level in sufficient detail, injury must have been sustained during sport participation, and data from at least 2 clinical follow-up visits. Patients were excluded if they had a history of learning disability, seizure disorder, attention deficit disorder, or were taking any form of medication during the testing periods.	3063 children between the ages of 5 and 17 y old reported to the emergency department within 48 h after initial head trauma. Subjects enrolled if they met the 2012 Zurich guidelines and excluded if they had any of the following: Glasgow coma scale of ≤13, abnormal CT, or MRI findings, any neurosurgical intervention, intubation, intensive care unit admission, multisystem injury, preexisting neurological developmental delay with communication difficulties, intoxication, absence of trauma, already previously enrolled in the same study, or the inability to follow-up.	103 subjects reported to the ED. Subjects were randomly allocated to either a no rest group (n = 51; age = 39.9 [14.5] y; sex = 52% male) or a rest group (n = 52; age = 34.1 [16.5] y; sex = 60% male). Subjects included if they were >15 y old, went to the ED ≤6 h after initial impact, had an absence of focal neurological symptoms, and met definition of a mild traumatic brain injury. Subjects excluded if multiple impacts, clinical observation was needed for their care, and a history of TBI, alcohol abuse, or psychiatric disorder.	370 patients were recruited for the study, but 178 were excluded due to exclusion criteria and 93 patients declined to participate. The remaining 99 participants were randomly allocated to 1 of 2 groups: usual care (n = 50) or strict rest (n = 49). The strict rest group was significantly older (14.7 vs 13.1 y). There were no other significant differences between the 2 groups at enrollment including weight, preinjury activity, mechanism of injury, reported signs and symptoms, or history of concussion.	50 college athletes (31 males and 19 females) were divided into two 25 subject groups based on whether their concussion was prior to a concussion management policy change (no rest group: 13 males and 12 females; age = 19.4 [1.3] y) or after the policy change (rest group: 18 males and 7 females; age = 19.8 [1.2] y; height = 1.73 [0.08] m; and weight = 80.9 [20.1] kg). Subjects were included if they recovered within 1 mo, had complete baseline data, and completed the specific return to play protocol. Subjects were excluded if they had a comorbid pathology or suffered another injury prior to return to play.
Intervention investigated	No intervention was prescribed. The primary purpose of this study was investigating the relationship between activity intensity after concussion and symptoms and neurocognitive outcomes up to 33 d after the concussion. It was hypothesized that athletes who engage in high levels of activity after a concussion have higher symptom severity scores and slower recoveries than those who engaged in lower activity levels during recovery. AIS was developed for analyzing the postconcussion activity level of an athlete. Activity levels were divided into 5 categories ranging from no activity to participation sports game. Data were derived from self-reported activity noted in the patient records by the clinician.	No intervention was prescribed. The researchers conducted an observational study by consenting each subject followed by collecting demographics, previous history of concussion, and acute concussion evaluation inventories. Parents and subjects quantified their preinjury and current symptoms using the PCSI. Each subject had a balance assessment, cognitive status, and physical examination completed by the child SCAT3. Subjects were categorized into either physical activity or no physical activity based off reported level of activity 7 d postenrollment.	Subjects were randomized into either no rest or full rest after their initial impact and the difference between groups is the amount of recommended bed rest. Subjects in the no rest group were told to remain active immediately and to bed rest for no more than 4 h on the first day, 3 h on the second day, 2 h on the third day, and 1 h on the fourth day. The no rest group was expected to bed rest for a maximum of 10 h over 4 d. Subjects in the full rest group were told to rest for the first 6 d following trauma and on day 7 were told to follow the same protocol as the no rest group regarding bed rest. The full rest group was expected to bed rest for a maximum of 82 h over 10 d.	Subjects were randomly allocated into 2 groups: strict rest (intervention) or usual care (control). Usual care allowed the attending physician to provide individualized recommendations based on the patient's medical status with or without activity restrictions. The strict rest group was provided recommendations and discharge instructions from the attending physician to maintain 5 d of strict rest (no school, work, or physical activity) followed by a stepwise return to activity progression. Each group also received the ACE-ED discharge instructions and encouraged to follow-up with their primary care physician or concussion clinic.	No true intervention was prescribed. The researchers compared those who suffered a concussion prior to the site-specific concussion policy change to those after the policy change to examine the effects of cognitive and physical rest on recovery. Those suffering a concussion prior to July 2012 were in the no rest group, meaning that cognitive rest and activities of daily living were not restricted, and those suffering from a concussion after July 2012 were prescribed cognitive rest and limited activities of daily living until asymptomatic. Both groups completed a standardized return to play protocol.

(continued)

Table 2 *(continued)*

	Study 1 (Majerske et al[10])	Study 2 (Grool et al[8])	Study 3 (de Kruijk et al[6])	Study 4 (Thomas et al[7])	Study 5 (Buckley et al[9])
Outcome measure(s)	Postconcussion symptom scores through the PCSS and ImPACT neurocognitive scores over time were utilized.	PPCS and early physical activity collected at 7 and 28 d postenrollment.	Both groups completed a 16-question PTC form, essentially a symptom checklist using a VAS for each symptom. A general health survey (SF-36) was also utilized. Both forms were administered at 2 wk, 3 mo, and 6 mo postimpact. No initial assessment with these forms was completed.	All subjects completed a retrospective activity diary of the current and previous day, the PCSS, the ImPACT, and BESS. All subjects reported for follow-up appointments at 3 and 10 d postinjury. All subjects completed an activity diary, the PCSS, ImPACT, BESS, and a neuropsychological test battery (Hopkins verbal learning test, trail making test, symbol digit modalities test, letter-number sequencing from the Wechsler scales, and controlled oral word association test) during each visit. Basal metabolic rate and total energy expenditure were estimated using demographic information collected during each appointment.	Each subject completed a baseline concussion assessment battery consisting of the GSC, ImPACT, the BESS, and the SAC. After suffering a concussion, the battery was administered the following day, and completed the GSC daily until asymptomatic. Once asymptomatic, the BESS and SAC were administered until reaching baseline values and ImPACT was administered every 2–3 d until baseline values were achieved.
Main findings	No statistically significant ($P = .08$) relationships were found between the symptom scores levels of activity. Poor performance in visual memory, visual motor speed, and reaction time was observed in patients engaging in highest activity levels. Multivariate regression analysis revealed that adjusted symptom scores decreased ($P < .001$) at each time interval, indicating improved symptom presence over time. Neurocognitive scores demonstrated improvements ($P < .002$) over time. A trend was observed between total symptom score and intensity of activity after concussion ($P = .08$). A main effect was noted for AIS score on visual memory ($P = .003$) and reaction time ($P < .001$). Evaluation of adjusted means suggests that athletes engaging in the highest activity levels (AIS = 4) had the worst visual memory scoring below the second percentile. Multivariate analysis suggests that athletes with AIS = 3 and AIS = 4 were more impaired in visual memory than AIS = 2 ($P = .05$ all comparisons).	At 7 d postenrollment, 1677 (69.5%) subjects reported participating in physical activity consisting of light aerobic activity to full return to competition with 523 (31.3%) reporting at least 3 persistent symptoms at day 7. By contrast, of the group participating in no physical activity since initial impact to day 7, 584 (79.5%) subjects reported 3 persistent symptoms at day 7. The researchers conducted a propensity 1:1 matching between groups and found that those in the early physical activity category remained consistently related with lower PPCS scores (n = 159 [28.7%] vs n = 222 [40.1%]). A subanalysis found that even those who returned to full contact activity reported significantly lower PPCS scores (14.5%) than those with no early physical activity (43.5%).	The no rest group bed rested for a mean duration of 17 h while the full rest group bed rested for a mean duration of 57 h. The full rest group found it harder to comply with recommended rest than the no rest group. The no rest group suffered statistically more dizziness and slightly more headache and nausea severity (not significant) than the full rest group at 2 wk postimpact. No significant differences were found in the PTC or SF-36 between groups at 3 months and 6 mo postimpact. The full rest group reported increased PTC values compared to the no rest group at 6 mo, but was not statistically significant.	There was no significant difference in total energy expenditure between groups, while the usual care group reported significantly more mental activity from days 2 to 5 (8.33 vs 4.86, $P = .03$). There was no significant difference in symptom resolution within the study period between the 2 groups (67% vs 63%, $P = .82$). The strict rest group reported greater PCSS scores (187.9 vs 131.9, $P < .03$), a greater quantity of postconcussive symptoms (70.4 vs 50.2, $P < .03$), and took twice as long for half of the group to report being asymptomatic. No significant differences were observed between groups in terms of ImPACT or BESS performance. The strict rest group performed significantly better than the usual care group on the symbol digit modalities test on day 3 (67.6 vs 59.9, $P < .01$) and significantly worse on day 10 (67.6 vs 71.5, $P = .04$).	The rest group remained symptomatic longer than the no rest group (5.2 [2.9] d vs 3.9 [1.9] d; $P = .47$). There were no significant differences between groups for the BESS, ($P = .18$) SAC ($P = .37$), or ImPACT ($P = .81$) assessments. In addition, time to clinical recovery was not significantly different between groups (rest 6.8 [4.6] d vs no rest 7.2 [5.8] d; $P = .81$). The no rest group suffered significant reductions in all 4 composite scores of the ImPACT test compared to the rest group only being reduced in the reaction time composite score.

(continued)

Table 2 *(continued)*

	Study 1 (Majerske et al[10])	Study 2 (Grool et al[8])	Study 3 (de Kruijk et al[6])	Study 4 (Thomas et al[7])	Study 5 (Buckley et al[9])
CEBM 2011 level of evidence	Level 3	Level 3	Level 2	Level 2	Level 3
Validity score	PEDro: 3/10	PEDro: 3/10	PEDro: 5/10	PEDro: 7/10	PEDro: 5/10
Conclusion	Activity intensity levels affected postconcussive symptoms. High-intensity activity showed poorer performance on neurocognitive measures. Moderate-intensity activity was reported to have the highest neurocognitive outcomes and lowest symptom score.	Early physical activity in adolescent patients within 7 d postconcussion was associated with lower PPCS scores than those who did not at 28 d postenrollment.	Early physical activity resulted in similar outcomes when compared to full rest after a "concussion." Applications to sports medicine settings are limited due to their use of mild traumatic brain injury instead of a concussion definition.	There was no significant difference in symptoms between strict rest or usual care during the initial 3 d following diagnosis of a concussion. However, strict rest during the 5 d immediately following a concussion resulted in greater overall PCSS scores, increased quantity of symptoms reported, and a delay in time to symptom resolution.	Currently recommended cognitive and physical rest increased duration of symptoms compared to the group receiving no modifications to cognitive activity and activities of daily living.

Abbreviations: ACE-ED, ACE-Emergency Department; AIS, activity intensity scale; BESS, balance error scoring system; CEBM, Centre for Evidence-Based Medicine; ED, emergency department; GSC, graded symptom checklist; ImPACT, immediate postconcussion assessment and cognitive test; PCSI, postconcussion symptom inventory; PCSS, postconcussion symptom scale; PPCS, persistent postconcussive symptoms; PTC, posttraumatic complaint; VAS, visual analog scale; SAC, standard assessment of concussion.

Summary of Best Evidence

Implications for Practice, Education, and Future Research

According to the 5th International Conference on Concussion in Sport, physical and cognitive rest were identified as potential avenues for improving recovery following a concussion.[1] Current recommendations for the management of SRC include cognitive and physical rest for a period of 24 to 48 hours followed by assimilation back to school prior to beginning a stepwise progression of physical activity to return to sport participation.[1] These conservative guidelines have been recommended to facilitate symptom resolution despite a lack of research supporting or refuting these recommendations.[1] Our findings suggest that early physical activity during the acute phase of concussion (0–7 d) may decrease symptom severity and duration and ultimately influence time missed from academics or sport. Each reviewed article compared either early physical activity to strict physical rest[7,8,10] or a combination of physical and cognitive rest[6,9]; however, interventions in the included studies were highly variable and inconsistent in the definition of concussion.

Restrictions on cognitive and physical activity were applied differently across the included studies. Two studies employed strict cognitive and physical rest for at least 5 days that included absence from school or work and bed rest following concussion.[6,7] de Kruijk et al[6] randomized participants to either bed rest followed by gradual activity or to stepwise activity over a 6-day period. Thomas et al[7] randomized participants to either strict physical rest for 5 days or to usual care consisting of 1 to 2 days of rest followed by progressive physical activity. Thomas et al[7] defined "usual care" as the clinical recommendations set by the attending physicians at the time the participant was admitted, including any cognitive or physical restrictions.

One study compared differences in concussed athletes at the college level before and after a sports medicine concussion policy change that altered their stepwise return to play guidelines.[9] Participants concussed after the policy change underwent physical and cognitive rest with full academic withholding for 1 day following initial head impact, with instructions to rest in a quiet environment. Participants concussed prior to the policy change did not receive any academic accommodation and were withheld from intercollegiate athletics if symptomatic, but were not restricted on any activity outside their athletic role.

The remaining 2 studies reviewed records of patients who were diagnosed with concussions with thorough assessments and analyzed symptom and physical activity patterns based on self-reported levels of activity.[8,10] Grool et al[8] prospectively assessed over 2500 patients that presented to emergency departments in Canada and examined the association between their amount of physical activity and persistent symptomology 7 days postconcussion. Majerske et al[10] retrospectively examined athletes who were assessed in the university's sports medicine concussion program. The researchers included only athletes who had thorough documentation of physical activity levels and academic status over at least 2 visits to determine the association of physical activity on postconcussion symptoms and neurocognitive performance.

During the first 10 days following a SRC, engaging in early physical activity was beneficial in reducing postconcussion symptoms. Participants who underwent strict physical rest resulted in a significantly longer symptom duration when compared to the physically active groups during the acute phase of concussion.[7–10] Early physical activity (0–7 d) resulted in a 32% reduction in 3 or more symptoms' presence and significant symptom resolution at 7 days postconcussion when compared to strict physical rest.[8] Strict physical rest also resulted in significantly more reported symptoms and symptom severity at 10 days postconcussion.[7]

Differences in symptom resolution were also observed between early physical activity and limited physical activity 1-month postconcussion.[6,8,10] Participation in early physical activity demonstrated an 11% absolute risk reduction for prolonged symptom recovery,[8] although the total quantity of reported symptoms was not significantly different.[6,10] Participation in high-intensity activity such as a sport game or competition was associated with increased symptom presence; however, moderate-intensity activity such as school attendance and sport practice was associated with the lowest risk of symptom presence.[10]

Although neurocognitive and balance assessments were not the primary variables of interest in the current review, they were assessed in 3 studies.[7,9,10] Limited evidence regarding neurocognitive and balance assessment was available to suggest that any treatment option was superior to another. Strict physical rest was superior within 24 hours of impact for neurocognitive and balance assessments, but was not significantly different between groups at 1 week postconcussion.[7,9] Participation in school and lower intensity activity was associated with the highest neurocognitive performance, whereas sport game or competition was associated with the poorest neurocognitive performance.[10] In addition, normalization of neurocognitive tests and balance assessments occurred at 1 to 2 weeks postconcussion, regardless of the subject's level of cognitive and physical rest.[7,9]

With the current level and quantity of research available, early physical activity appears to reduce symptom severity and duration in comparison to strict physical rest. However, this conclusion is based on limited available literature, quality of evidence, and diverse interventions studied. Our conclusions should not override current consensus guidelines[1,2] but should serve as a spotlight to the best available evidence surrounding early physical activity following a concussion. Patients who are asymptomatic have not recovered physiologically, highlighting the importance of a patient-specific and evidence-based approach to achieving symptom resolution. Physical activity should be conducted in a controlled and supervised environment. The clinician should perform a daily assessment of symptom presence, and physical activity should be kept below the symptom threshold.

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