Light Physical Activity and Improving Symptoms of Sport-Related Concussions in Pediatrics

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Recommended Citation
Wilson, Brittany and Dechape, Kai, "Light Physical Activity and Improving Symptoms of Sport-Related Concussions in Pediatrics" (2017). School of Physician Assistant Studies. 624.
https://commons.pacificu.edu/pa/624
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Abstract

Background: The current guidelines for managing a sport-related concussion include physical and cognitive rest until acute symptoms resolve, followed by a graded program of exertion before medical clearance. However, this consensus does not address children less than 13 years of age. Children are physically, cognitively, and emotionally very different from adults and there is evidence that younger athletes take longer to recover after a concussive injury. Currently, there is no specific timeframe for how long prescribed rest should last if individuals do not recover as expected. The purpose of this systematic review is to address the use of light physical activity as a treatment modality for children and adolescents who are slow to recover from a sport-related concussion.

Methods: An exhaustive literature search using MEDLINE-Ovid, MEDLINE-PubMed, Web of Science, and Google Scholar was conducted using keywords: brain concussion and exercise therapy. Articles were screened with eligibility criteria and the resulting studies were then appraised and assessed for quality with GRADE.

Results: Two pilot studies were included in this systematic review that met the inclusion criteria and were conducted by similar groups of researchers. One study of 16 children and adolescents who were slow to recover from a sport-related concussion found that involvement in an active rehabilitation program in the post-acute period may promote recovery. The second study of 10 adolescents found that the utilization of graded light-intensity exercise in the post-acute period following concussion is safe, feasible, and appears to be an effective intervention for adolescents who are slow to recover from a sport-related concussion.

Conclusion: In synthesizing the results from these two pilot studies, the consensus was that light physical activity may have utility in providing symptomatic improvement in sport-related pediatric concussions. Future clinical trials with larger populations, randomization, control groups, and varied timeframes for introducing light physical activity post-concussion are recommended. This upcoming research could change the way clinicians evaluate and manage pediatric concussions.

Keywords: Concussion, pediatric, sports, physical activity, rehabilitation, children, adolescents, brain concussion, brain injury, exercise therapy, sports medicine.

Degree Type
Capstone Project

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Subject Categories
Medicine and Health Sciences

This capstone project is available at CommonKnowledge: https://commons.pacificu.edu/pa/624
Light Physical Activity and Improving Symptoms of Sport-Related Concussions in Pediatrics

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A Clinical Graduate Project Submitted to the Faculty of the School of Physician Assistant Studies
Pacific University
Hillsboro, OR
For the Masters of Science Degree, August 12, 2017
Faculty Advisor: Dr. Mark Pedemonte, MD
Clinical Graduate Project Coordinator: Annjanette Sommers, PA-C, MS
Biography

[Redacted for privacy]
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Acknowledgements

[Redacted for privacy]
Table of Contents

Biography 2
Abstract 3
Acknowledgements 4
Table of Contents 5
List of Tables 5
List of Abbreviations 5
Background 6
Methods 7
Results 8
Discussion 12
Conclusion 144
References 16

List of Tables

Table 1: Quality Assessment of Reviewed Articles

List of Abbreviations

mTBI: Mild Traumatic Brain Injury
MCH-RAC: Montreal Children’s Hospital Rehabilitation After Concussion
BOTMP-2: Bruininks-Oseretsky Test of Motor Proficiency
BESS: Balance Error Scoring System
RTP: Return to play
RCT: Randomized Control Trial
Light Physical Activity and Improving Symptoms of Sport-Related Concussions in Pediatrics

BACKGROUND

Concussion is a major health concern in the pediatric population. Children are physically, cognitively, and emotionally very different from adults and require the use of a different set of tools for the diagnosis, recovery-assessment, and management of concussion.\(^1\) Despite a proficiency in the diagnosis of concussion, pediatric physicians exhibit a wide variation in recommending graduated return to play (RTP) and cognitive rest following concussion.\(^2\) The current consensus recommendation for managing a sport-related concussion is physical and cognitive rest until the acute symptoms resolve and then a graded program of exertion before medical clearance and RTP.\(^3\) However, this recommendation does not include children less than 13 years of age and has very little data and recommendations regarding management of pediatric concussions.

One common problem in pediatrics has been the overenthusiastic prescription of rest after concussion.\(^4\) Several days of rest has proven to be beneficial during the acute period in which there is cerebral metabolic disruption.\(^5\) Evidence suggests that more than this is not beneficial.\(^6\) In fact, prolonged rest, especially in athletes, can lead to physical deconditioning, metabolic disturbances, and secondary symptoms, such as fatigue and reactive depression.\(^7\) Evidence also shows that individuals who are recommended to have a prolonged period of cognitive rest could actually suffer from a longer duration of symptoms than those who are not.\(^8\)

There is evidence that younger athletes take longer to recover after a concussive injury than adults.\(^1,9\) College and professional athletes take an average of 3-7 days to
recover from a concussion whereas high school athletes take an average of 10-14 days to heal, and it is suggested that preadolescent children take longer than that. The problem for clinicians is that a series of agreement and consensus statements have recommended that athletes should rest until they are asymptomatic; these statements do not specify a timeframe for how long prescribed rest should last if individuals do not recover as expected; and there are no evidence-based guidelines for providing treatment and rehabilitation services to athletes who are slow to recover.

From a practical perspective, athletes need to, and naturally will, transition back into an active lifestyle. Contrary to current recommendations, most children still experiencing concussion symptoms resume exercising a week after being injured, and more than three-quarters are physically active 2 weeks later. In general, there is little support for bed rest as a form of management for a multitude of health problems, and it may actually delay recovery and even harm the patient. Exercise assessment and aerobic exercise training may reduce concussion-related physiological dysfunction by restoring autonomic balance and by improving autoregulation of cerebral blood flow. The purpose of this systematic review is to address the use of light physical activity as a treatment modality for children and adolescents who have suffered from a sport-related concussion.

METHODS

An exhaustive literature search was conducted using MEDLINE-Ovid, MEDLINE-PubMed, Web of Science, and Google Scholar. To search for articles evaluating the effect of light physical activity on concussion symptoms, the following search terms
were used: brain concussion and exercise therapy. The references from relevant articles were also reviewed. Included were studies conducted on children and adolescents with a sport-related concussion, evaluating light physical activity in comparison to current concussion treatment guidelines, and measuring symptomatic improvement. Other inclusion criteria required studies published in the English language, human studies, studies on patients between 7 and 18 years old, studies on patients with at least 4 weeks of post-concussion symptoms, and studies from the last 10 years. Studies were excluded if patients were diagnosed with a mild traumatic brain injury (mTBI) or if patients began light physical activity within the first 4 weeks post-injury. Additionally, studies that didn’t supply data regarding patient response to therapy were excluded. The quality of relevant articles was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group guidelines.\textsuperscript{16}

RESULTS

The initial literature search revealed 127 potential articles for review. After eliminating duplicates and screening abstracts and titles for eligibility, 2 articles were selected that met inclusion criteria. These articles were both pilot studies.\textsuperscript{11,17} (See Table 1.) Another prospective case series\textsuperscript{18} was considered, but fell under exclusion criteria because the population was not specific to the pediatric population.

Gagnon et al (2009)\textsuperscript{17} was the first pilot study to research the effects of light physical activity in improving symptoms of sport-related concussions in pediatrics. This study was conducted over a 2 year period in Montreal, Canada and was published in
2009. A group of 16 children and adolescents with slow recovery post-concussion were followed, 5 of which were female and 11 male. All children and adolescents were aged between 8 and 17 years old and were diagnosed with a concussion by a physician. All patients were referred to Montreal Children’s Hospital Rehabilitation After Concussion (MCH-RAC) intervention after experiencing persistent post-concussion symptoms for at least 4 weeks. The MCH-RAC is an intervention for children and adolescents who do not recover in the initial days or weeks following the injury, either because they may have a more severe injury than initially thought or they may present with pre-injury characteristics placing them at risk of developing more chronic symptoms.\(^{17}\)

The patients’ concussions were caused by either rugby, soccer, kayaking, football, cheerleading, skiing, or hockey. The major chief complaint upon presentation to the MCH-RAC intervention was headache, but others included fatigue, poor endurance, and feeling depressed. Prior to their involvement in the MCH-RAC program, children completed baseline assessment measures including standard neurological and physical examination, balance using the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP-2) and in some cases the Balance Error Scoring System (BESS), coordination testing using the BOTMP-2, and a post-concussion symptoms checklist. After patients were assessed, they began a graded active rehabilitation.\(^{17}\)

The initial visit included an aerobic training either on a treadmill or stationary bicycle for 5-15 minutes. On subsequent visits, children were introduced to light coordination exercises tailored toward their main sport of interest. Patients were monitored closely for any increase in symptoms during the physical activities, at which point the activities were stopped. The last step of the MCH-RAC intervention was to
create a home program in order to allow children to continue training outside the clinic. The home program included supervised sub-maximal aerobic training and coordination exercises for the duration the child was able to tolerate without symptoms increasing. The children were followed weekly until they reported being symptom-free at rest for one week, at which point they could enter the standard return to activity protocol. The duration of involvement in MCH-RAC before resolution of symptoms ranged anywhere between 2 and 12 weeks with a mean of 4.4 weeks.\textsuperscript{17}

Symptom improvement was graded using the Post-Concussion Scale Revised Score. The Post-Concussion Scale\textsuperscript{19} objectively documents the often highly subjective symptoms reported by athletes following concussion by assigning numeric values to each symptom. There are 22 symptoms included in the scale and each can receive a score from 0-6 depending on the severity determined by each patient. The mean score for the participants at initial assessment was 30.0 and decreased to 6.7 at discharge from the program. All 16 participants in this study showed significant and rapid improvement of symptoms and were able to resume their normal physical activity participation at the end of the intervention.\textsuperscript{17}

Gagnon et al (2015),\textsuperscript{11} a follow up study to Gagnon et al (2009),\textsuperscript{17} further evaluated the effects of graded light intensity exercise in the post-acute period following sport-related adolescent concussions. This study was conducted over a 4-month period in Montreal, Canada and was published in 2015. A group of 10 adolescents with slow recovery post-concussion were followed, 3 of which were female and 7 were male. All adolescents were aged between 14 and 18 years of age and were diagnosed with a concussion by a physician. Similar to the previous study, all patients were referred to
Montreal Children’s Hospital Rehabilitation After Concussion (MCH-RAC) intervention after experiencing persistent post-concussion symptoms for at least 4 weeks.\textsuperscript{11}

The adolescents’ concussions were caused by either soccer, football, basketball, hockey, or snowboarding. Headache was the symptom most often endorsed prior to the intervention, but other presenting symptoms included fatigue, dizziness, balance, concentration, and visual abnormalities. All adolescents had been screened acutely for co-existing cervical, oculomotor, and vestibular impairments but did not need interventions for these potential problems. Prior to their involvement in the MCH-RAC program, adolescents completed baseline assessment measures including the Post-Concussion Scale for symptoms, Beck Depression Inventory - Second Edition for mood, Pediatric Quality of Life Multidimensional Fatigue Scale for energy level, Bruininks-Oseretsky Test of Motor Proficiency (BOTMP-2) for balance and coordination, ImPACT for cognitive functioning, and the State Trait Anxiety Inventory for parental anxiety.\textsuperscript{11}

After patients were assessed, they began a 4-step rehabilitation intervention. The first step was to provide adolescents with an aerobic training intervention in which patients could choose between walking/light jogging on a treadmill or using a stationary bicycle for a maximum of 15 minutes. Next, up to 10 minutes of coordination exercises were tailored to the adolescents’ preferred sport or physical activity. Third, the adolescent was introduced to visualization and imagery techniques to promote positive experiences regarding physical activity participation. The last step of the MCH-RAC intervention was to create a home program in order to allow adolescents to continue training outside the clinic. The home program was monitored with a treatment log and done for 20-30 minutes per day. The participants were assessed at approximately 10-
day intervals by the clinical team during the 6-week study period to examine the short-term effects of the rehabilitation intervention. The duration of involvement in MCH-RAC before resolution of symptoms ranged anywhere between 2.2 - 15.2 weeks with a mean of 6.8 weeks.\textsuperscript{11}

Post-Concussion Scale total scores showed a large and significant decrease over the 6-week follow-up period for all 10 adolescents, even though some were still involved in the rehabilitation program at that time. All participants showed a significant decrease in fatigue when comparing pre- and post-intervention. Cognitive function also significantly improved in the visual motor processing speed domain, but remained similar between pre- and post-intervention in the other composite scores. Depression scores showed significant improvement after the program. Motor proficiency scores also showed an improvement, but were not significant due to small sample size. Lastly, parental anxiety did not change between pre- and post-intervention.\textsuperscript{11}

**DISCUSSION**

Current concussion protocols endorse the conservative view that children should avoid physical activity until completely symptom-free; however, little evidence beyond expert opinion has informed the return to play, graduated timing, and type.\textsuperscript{13} Gagnon et al (2009)\textsuperscript{17} and Gagnon et al (2015)\textsuperscript{11} both examined the effectiveness of an active rehabilitation intervention for children and adolescents who were slow to recover after a sport-related concussion. In synthesizing the results from these two pilot studies, the consensus was that light physical activity does have utility in providing symptomatic improvement in sport-related pediatric concussions. Specifically, Gagnon et al (2009)\textsuperscript{17}
demonstrated an average time to RTP in the study’s participants to be 4.4 weeks and Gagnon et al (2015) showed an average of 6.8 weeks. With up to 29% of children nationwide continuing to have post-concussion symptoms past 3 months, these studies illustrate the potential of light physical activity in treating patients with slow-to-recover concussion.

While both studies demonstrate this clear finding, they present with some major limitations (see Table 1). The research on this subject is relatively new; therefore research is in its early stages. The two pilot studies being reviewed were both case series conducted by similar groups of researchers. They were both conducted at the same facility (Montreal Children’s Hospital Rehabilitation After Concussion), which limits the value of the results and conclusions.

Moreover, the relevance of both studies were limited by small sample sizes considering the Gagnon et al (2009) study had 16 participants and the Gagnon et al (2015) study had 10 participants. Although the studies mention that they included children and adolescents between 8 and 18 years old, it was discovered that only one participant of the total was 8 years old and the rest were teenagers. Future research can include larger populations with more diverse age ranges.

The absence of a control group in both studies allowed for lack of randomization and allocation concealment. This deficiency of a comparison group also leads to indirectness as inferences had to be made about the relative effect of light physical activity as compared to standard concussion treatment. The lack of a control group limits the possibility of estimating placebo effects or other factors that might have influenced individual outcomes. Future studies can minimize this deficit by including a
comparison group.

The two pilot studies were consistent and precise in their findings considering they evaluated the same active rehabilitation program at the same hospital. This commonality helps to strengthen the clinical question due to the fact that the subjects from both studies were screened and evaluated in the same manner. Because these studies only evaluated children and adolescents experiencing persistent post-concussion symptoms for at least 4 weeks, future studies could evaluate introducing light physical activity in earlier timeframes. Obviously, there is a strong need for further randomized control trials (RCTs) evaluating the effects of light physical activity in improving pediatric concussion-related symptoms.

Although there are no RCTs that have been published on this subject to date, there are 2 RCTs currently in progress. An RCT protocol\textsuperscript{21} of 100 youth is currently comparing the effects of an adapted form of the active rehabilitation protocol reported by Gagnon et al\textsuperscript{11,17} that includes blinded outcome assessment. Another large RCT\textsuperscript{13} of 3063 children aged 5-18 years is currently being peer reviewed before publication and demonstrated that early physical activity following injury was associated with reduced persistent post-concussive symptoms.

**CONCLUSION**

Current clinical evidence for the management of concussions is limited in the pediatric population. Rest has been widely prescribed as a treatment; however, there is insufficient research on the possible negative effects for patients who are slow to recover. In addition, there is evidence that younger athletes take longer to recover from
a concussive injury than adults. Ultimately, the effect of early physical activity following concussion has been underexplored. There is a potential for changing clinical practice towards light physical activity, specifically in patients who are slow to recover from concussion symptoms.

Future research with larger populations, comparison groups, and varied timeframes for introducing light physical activity post-concussion is recommended. Additional clinical trials with this evidence will help clinicians to make better recommendations regarding graded light physical activity and ultimately, return to play. This upcoming research could cause a major shift in concussion management and have a significant impact on the well being of children and families worldwide.
REFERENCES


changes in functional magnetic resonance imaging activation, physiology, and symptoms. *The Journal of Head Trauma Rehabilitation*, 28(4), 241-249. doi:10.1097/HTR.0b013e31826da964


## TABLE 1. Quality Assessment of Reviewed Articles

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<tr>
<th>Study</th>
<th>Study Design</th>
<th>Limitations</th>
<th>Indirectness</th>
<th>Inconsistency</th>
<th>Imprecision</th>
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<td>Gagnon et al (2009)¹⁷</td>
<td>Case Series</td>
<td>Very Serious ¹</td>
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¹Lack of control group and small sample size, randomization, and allocation concealment
²Head-to-head comparisons are unavailable therefore inferences are made about the relative effect of light physical activity vs. standard concussion treatment