The Effectiveness of Physical Therapy Exercise Interventions for Concussions

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The Effectiveness of Physical Therapy Exercise Interventions for Concussions

A Capstone Submitted to the

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With Honors

Department of

Kinesiology and Physical Education

By

Anna Altergott

DeKalb, Illinois

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The Effectiveness of Physical Therapy Exercise Interventions for Concussions

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Faculty Approval Signature __________________________

Department of (print or type) _______ Kinesiology and Physical Education _________

Date of Approval (print or type) ___ 11/27/23 ______________________________________

Date and Venue of Presentation _12/7/23 at Peters Campus Life Building Atrium

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ABSTRACT

This project was a systematic review exploring exercise interventions for individuals who sustain a concussion. While it has been suggested for many years that people with concussions should avoid physical and mental activity, there have been many findings and studies that indicated exercise training can reduce symptoms and improve function for those experiencing persistent post-concussion symptoms. Aerobic exercise represents a potentially useful and clinically pragmatic rehabilitation technique if done in a safe and controlled manner as guided by a trained clinician, such as, a physical therapist. There are specific exercise interventions that are discussed below to find which intervention is the most effective. This review will provide a summary of various evidence-based interventions and identify the outcomes of each. These interventions include sub-symptom threshold aerobic exercise, Get Going After Concussion (GAIN) Intervention, and Vestibular Treatment in Concussion. The data was consistent in that exercise interventions showed improvements in time to recovery and reduction of post-concussion symptoms in patients who have suffered from a concussion.
Introduction

Traumatic brain injury (TBI) are common medical injuries. TBI is caused by a direct blow to the head or neck, which creates a disturbance in how the brain functions (Patricios et al., 2022). Individuals who have or are suffering a concussion can use physical exercise as an approach to healing. The typical treatment methods for concussions include cognitive and physical rest but this approach does not work all the time (Howell, 2020). 50% of individuals who sustain concussions continue to exhibit symptoms even after medical clearance (Theadom et al, 2014). Studies have even indicated that both central and systemic physiological dysfunction can contribute to exercise intolerance after traumatic brain injury. Also, according to Theadom et al. (2014), “Given the high incidence of new and recurrent traumatic brain injury and the high risk of complications following injury, further sport specific injury prevention strategies are urgently needed to reduce the impact of traumatic brain injury and facilitate safer engagement in sports activities” (p. 1).

Physical therapists treat many patients with many different types of injuries. Treatment may include stretches, strength and motion exercises, hands-on technique, or the use of technology (APTA, 2017). An individual who has suffered a concussion has many difficulties making sure they have recovered properly. “Physical therapists help people with TBI regain their physical function, relearn daily tasks, and restore their fitness and wellness” (APTA, 2017, p. 1). With physical therapy, the use of repetitive practice of targeted exercises can help activate neuroplasticity, which is the ability of the brain to form and reorganize synaptic connections, especially in response to learning or experience or following injury, in an individual who has suffered a concussion (Fong, 2023). With neuroplasticity, the
brain can change and heal itself (Fong, 2023). Neuroplasticity may play a role but there is not enough research to take place to create a systematic review on just neuroplasticity and post-concussion interventions. According to Fong (2023), “with the right therapy, we can promote neuroplasticity in the affected neural network. This helps the brain to correct its signaling and use the right region for the right process and in the right way. Because of neuralplasticity, your brain can restore connections to make that change happen” (p. 1). Aerobic exercise at an intensity level that does not increase symptoms has received increasing focus in rehabilitation of patients with a concussion. This is why it is important to develop an evidence-based exercise plan for a patient who is suffering from a concussion. Figure 1 displays the aspect patients and clinicians should consider when deciding on an exercise intervention. Each treatment plan should be personalized based the patient’s overall health and fitness level. The aim of this systematic review was to investigate the effectiveness of physical therapy exercise interventions for individuals who have sustained a concussion.

Figure 1: Aspects to consider for patients needing exercise interventions (Howell et al., 2020).

MATERIALS AND METHODS
Study Eligibility Criteria

Included studies had to be from primary publications and assess participants who sustained a concussion and physical therapy or exercise intervention(s). Studies consisted of a randomized controlled trial, case-control study, or clinical trial.

Articles were excluded if they were not of a primary publication, not reported in English, or did not fit the inclusion criteria stated. Also, participants with unspecified brain injuries, neurological or severe psychiatric conditions, cardiovascular disease that contraindicates exercise testing, extremity injuries that prevent physical exercise, or who sustained a concussion from a motor vehicle accident since these studies focused more on sport related head injuries.

Search Strategy

The systematic review will allow us to thoroughly search the existing literature to synthesize the evidence related to exercise-based interventions following concussion utilizing the established preferred reporting items for systematic reviews and meta-analyses (PRISMA, 2015). This review conforms to all Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA, 2015) guidelines to improve the transparency and scientific merit of a reported study. The following databases were utilized for the search: PubMed, SCOPUS, and CINAHL. The search algorithm included all possible combinations of key words: concussions, physical therapy interventions, exercise, function, effectiveness, and symptom, quality of life. These terms were chosen to ensure that all possible variations were included in the search.

Study Quality Assessment
To consider the validity and rigor of the research credibility of the findings and how useful and relevant the findings are the study quality was assessed using the following 11 criteria adapted from Littell et al. (2008): (1) Was the research question clearly stated? (2) Were the inclusion and exclusion criteria clearly stated? (3) Was the assessment conducted 14 days after sustaining the injury? (4) Were the main findings of the study clearly stated? (5) Did healthy controls' age and sex match those of the concussed subjects? (6) Were the walking and/or balance tasks clearly stated? (7) Were the walking and/or balance tasks uniformly applied to all participants? (8) Were the walking and/or balance tasks appropriate for the subject population? (9) Was a power analysis used to justify sample size? (10) Were potential confounders properly controlled for? (11) Were assessors blinded to incidence of concussion? Each of the 11 criteria was scored on a scale of 0 to 2. This study quality was used to assess the risk of bias and consider the importance of outcomes. Table 1 outlines the summative findings of the study quality assessment.

Table 1: Study quality assessment

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Was the research question clearly stated?</td>
<td>2.0</td>
</tr>
<tr>
<td>Were the inclusion and exclusion criteria clearly stated?</td>
<td>1.5</td>
</tr>
<tr>
<td>Was the assessment conducted 14 days after sustaining the injury?</td>
<td>0.2</td>
</tr>
<tr>
<td>Were the main findings of the study</td>
<td>2.0</td>
</tr>
<tr>
<td>Question</td>
<td>Score</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Did healthy controls' age and sex match those of the concussed subjects?</td>
<td>1.0</td>
</tr>
<tr>
<td>Were the walking and/or balance tasks clearly stated?</td>
<td>1.3</td>
</tr>
<tr>
<td>Were the walking and/or balance tasks uniformly applied to all participants?</td>
<td>1.6</td>
</tr>
<tr>
<td>Were the walking and/or balance tasks appropriate for the subject population?</td>
<td>1.9</td>
</tr>
<tr>
<td>Was a power analysis used to justify sample size?</td>
<td>0.8</td>
</tr>
<tr>
<td>Were potential confounders properly controlled for?</td>
<td>1.1</td>
</tr>
<tr>
<td>Were assessors blinded to incidence of concussion?</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>Total Score</strong></td>
<td><strong>14.1</strong></td>
</tr>
</tbody>
</table>

Scores for each criterion range from 0 to 2, depending on whether the criterion was not met (0), partially met (1), or completely met (2). The total study score ranges between 0 and 22.

**RESULTS**
Figure 2 displays the study selection flow chart. There are three articles included in this systematic review.

**Figure 2: Study Selection Flow Chart**

![Study Selection Flow Chart Diagram](image-url)
Study Characteristics

Exercise interventions for the treatment groups were used for all three studies. The control groups for each of the studies either participated in rest, sub-therapeutic exercise, or placebo. The outcome measures varied throughout the three studies and included: Rivermead Post-Concussion Symptoms Questionnaire, Buffalo Concussion Treadmill Test, Health related quality of life and activity limitations, Utrecht Scale for Evaluation of Rehabilitation Participation, Vertigo Symptom Scale, Hospital Anxiety and Depression Scale, Balance Error Scoring System, and between-group differences using a linear mixed-model analysis for repeated measurements. See table 3, 4, and 5 for specific descriptions of each outcome intervention. In total, there was 345 participants between the three studies aging between 15-60 years of age. All studies included participants that suffered from post-concussion symptoms.

Table 2: Summary of each study which includes author/year, location of study, if controls where included, the sample size, age of the sample, and gender make-up

<table>
<thead>
<tr>
<th>Study</th>
<th>Author</th>
<th>Year</th>
<th>Location of Study</th>
<th>Controls</th>
<th>Sample Size</th>
<th>Age of the Sample</th>
<th>Gender Make-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-symptom threshold aerobic exercise</td>
<td>Lars-Johan V. Valaas, Helene L. Soberg, Mari S. Rasmussen, Sophie E. Steenstrup, Nada Andelic, Ingerid Kleffelgård</td>
<td>2023</td>
<td>TBI outpatient clinic at the Department of Physical Medicine and Rehabilitation, Oslo University Hospital</td>
<td>Yes</td>
<td>120 participants for this trial (60 in each group)</td>
<td>18-60</td>
<td>Does not specify how many women and how many men but there is a mix of both</td>
</tr>
<tr>
<td>Study Design</td>
<td>Main Outcome Measures</td>
<td>Summary of the Protocol</td>
<td>Summary of the Results</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GAIN</td>
<td>Erhard Trillingsgaard Næss-Schmidt, Mille Møller Thastum, Henriette Holm Stabel, Lene Odgaard, Asger Roer Pedersen, Charlotte Ulrikka Rask, Noah D. Silverberg, Andreas Schröder, Jørgen Feldbæk Nielsen</td>
<td>Central Denmark region</td>
<td>Yes</td>
<td>2022</td>
<td>180</td>
<td>15-30</td>
<td>Does not specify how many women and how many men but there is a mix of both men and women</td>
</tr>
<tr>
<td>Vestibular Rehabilitation</td>
<td>Ingerid Kleffelgaard, Helene Lundgaard Soberg, Anne-Lise Tamb er, Kari Anette Bruusgaard, Are Hugo Pripp, Maria Sandhaug, Birgitta Langhammer</td>
<td>University Hospital (recruitment and baseline assessments) and Metropoli tan University (experimental intervention)</td>
<td>Yes</td>
<td>2018</td>
<td>65</td>
<td>16-60</td>
<td>45 women, 20 men</td>
</tr>
</tbody>
</table>

Table 3: Sub-Symptom Threshold Aerobic Exercise Summary
The primary outcome is symptom burden measured with the Rivermead Post-Concussion Symptoms Questionnaire (RPQ). The secondary outcome is exercise intolerance measured with the BCTT. Other outcomes include headache symptoms and severity, fatigue, anxiety, psychological distress, depressive symptoms, estimates of physical activity, health-related quality of life and activity limitations, and adherence to the intervention.

The main purpose of this study is to evaluate whether SSTAE in addition to ordinary rehabilitation will lead to clinically meaningful improvement of symptom burden, normalize exercise tolerance, increase physical activity, improve health-related quality of life, and reduce patient-specific activity limitations compared to a control group that only receives ordinary rehabilitation.

Randomized, controlled, single-blind parallel-group study with three measurement times; T0 at baseline, T1 after the intervention and T2 six months after T1.

Results from the primary and secondary outcomes were satisfactory in that they showed that most patients in the feasibility study reported reduced symptom burden and were able to exercise at a higher intensity level after 12-weeks of SSTAE. SSTAE is safe, reduces PPCS, and may contribute to fewer activity limitations and increased participation.

<table>
<thead>
<tr>
<th>Study Design</th>
<th>Main Outcome Measures</th>
<th>Summary of the Protocol</th>
<th>Summary of the Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Randomized Trial</td>
<td>Primary outcome: Severity of post-concussion symptoms covering physical, cognitive, and emotional symptoms using the Rivermead Post Concussion Symptoms</td>
<td>“Get going After concussion (GAIN)”, that incorporates multiple evidence-based strategies including prescribed exercise, cognitive behavioral therapy, and gradual return to activity</td>
<td>Decrease in symptoms, no adverse affects</td>
</tr>
</tbody>
</table>

Table 4: Get Going After Concussion Intervention Summary
<table>
<thead>
<tr>
<th>Study Design</th>
<th>Main Outcome Measures</th>
<th>Summary of the Protocol</th>
<th>Summary of the Results</th>
</tr>
</thead>
</table>
| Single-Blind Randomized Controlled Trial | Primary outcome: Dizziness Handicap Inventory.  
Secondary outcome: High-Level Mobility Assessment Tool.  
Other outcomes: Vertigo Symptom Scale; Rivermead Post-concussion Symptoms Questionnaire; Hospital Anxiety and Depression Scale; and Balance Error Scoring System. Between-group differences were analyzed with a linear mixed-model analysis for repeated measurements. | Group-based vestibular rehabilitation for eight weeks (oculomotor system, vestibulo-ocular reflex). Consisted of guidance, individually tailored exercises, a home exercise program, and an exercise diary | At baseline, no group differences were revealed. At the first follow-up, statistically significant mean differences in favor of the intervention were found in the primary and secondary outcomes. At the second follow-up, no significant between-group differences were found. No significant between-group differences in the other outcomes were found at the two follow-ups. |
RESULTS OF INDIVIDUAL STUDIES

Sub-symptom threshold aerobic exercises

The Sub-Symptom Threshold Aerobic Exercise (SSTAE) intervention comprises of exercise at an intensity level that does not increase symptoms (Valaas et al, 2023). It is a treatment to reduce the symptom burden and increase the exercise tolerance after the injury (Valaas et al, 2023). The intervention comprises consultations, Bufalo Concussion Treadmill Test (BCTT) testing and a personalized exercise program. Each patient had their own personalized exercise program. The patients were instructed to perform aerobic exercise in their preferred mode at an intensity of 80-90% of the symptom threshold. Each session followed the exact same plan: 5-10 minutes of warm up, 20 minutes of aerobic exercise at sub-symptom threshold intensity, 5-10 minutes of active cool down. The intensity of each patient was monitored using a heart rate monitor and/or Borg RPE scale. If symptoms exacerbate during an exercise session with ≥3 NRS, or perpetuate the following days, the patients are advised to reduce the HR with 5–10 beats/minute to reduce the Post Concussion Symptoms (PPCS) (Valaas et al, 2023). As physical therapists the exercise frequency is decided together by patient and therapist. Each individual attended from 3 to 5 sessions per week. Patients were also offered a two guided treadmill sessions the first two weeks of intervention in addition to a new BCTT at week 3, 6, 9 prior to T1 after 12 weeks (Valaas et al, 2023). Compliance with the SSTAE was recorded using an exercise diary in order to keep track of their current aerobic level as well as identify any improvements. This will compose the basis for the consultations focusing on supporting, motivating, and reassuring the patients. The control group is followed up with assessments and BCTT at baseline (T0), after 12 weeks (T1) and six months (T2) only (Valaas et al, 2023).
Get Going After Concussion (GAIN) Intervention

The first GAIN trial was delivered in a specialized hospital setting, among adolescents and young adults (15-30 years) (Naess-Schmidt, 2022). In a randomized design, people having had a concussion receiving Enhanced Usual Care (EUC) plus Get Going After Concussion (GAIN) (EUC + GAIN) showed a significantly larger reduction in post-concussion symptoms (PCS) 3 months post-intervention compared to participants receiving Enhanced Usual Care (EUC) only (Naess-Schmidt, 2022). But there was a concern about how to manage persistent PCS. GAIN 2.0 was tested on a broader range of participants and evaluated whether GAIN promotes people’s return to work and participation in everyday activities.

A 8-week interdisciplinary intervention program (EUC + GAIN) against EUC only was looked at in a stepped wedge cluster randomized design. The stepped wedge cluster randomized trial involves the sequential transition of clusters, such as, hospitals or communities) from control to intervention conditions in a randomized order (Hemming 2022). It consisted of five clusters and six periods of each 3 months long.

Primary outcome is mean change in PCS level as measured by the Rivermead Post Concussion Symptoms Questionnaire (RPQ) which is a 16-item, self-reported scale measuring the severity of PCS including physical, cognitive and emotional symptoms, within the past 24 h compared to before the injury on a five-point scale (ranging from 0 “not experienced at all” to 4 “a severe problem”). Also, participation in instrumental activities of daily living (IADL) at 3 months after end of treatment measured on time spend on daily activities, experienced limitations, and satisfaction with participation on the Utrecht Scale for
Evaluation of Rehabilitation-Participation (USER-P) which is a disease-nonspecific questionnaire that measures IADL such as work, voluntary work, education, family duties and responsibilities, leisure activities, transportation, communication, and social activities (Naess-Schmidt, 2022). All self-reported outcomes are measured at baseline (within 1 week before clinical examination), at end of treatment and at 3, 6 and 18 months after end of treatment. Additionally, RPQ, Behavioural Response to Illness Questionnaire (BRIQ) and Brief Illness Perception Questionnaire (B-IPQ) are measured four times during intervention in the EUC + GAIN group (Naess-Schmidt, 2022).

The results have shown that in GAIN 1.0, they found a mean difference in the improvement of 7.6 points between EUC + GAIN and EUC on the RPQ 3 months after end of treatment. In GAIN 2.0, a difference in the improvement of 7 points between groups on the RPQ. With the assumptions of a population mean RPQ change of 9.3 points of EUC + GAIN compared with EUC, measurement variance of 137, a variance between clusters of 0.97, a statistical significance level of 5%, and a statistical power of 80% (Naess-Schmidt, 2022).

**Vestibular Treatment in Concussion**

Two groups, a control and intervention group, were offered the usual multidisciplinary outpatient rehabilitation comprising clinical examinations and assessments and follow-ups. Patients in the intervention group received a group-based vestibular rehabilitation intervention twice weekly for eight weeks. Attending all 16 sessions was considered 100% adherence to the intervention. The set of interventions consisted of guidance, individually tailored exercises, a home exercise program, and an exercise diary (Kleffelgaard, 2018). The intervention was mainly based on principles from motor control theory for improving
balance. Elements from established vestibular rehabilitation interventions were included and followed the principles of habituation, adaptation/gaze stability, substitution exercises, and balance relearning (Kleffelgaard, 2018).

There were no major differences in baseline characteristics between the groups in terms of personal factors, clinical characteristics, and outcome measures or in participation in the multidisciplinary rehabilitation and/or the psychoeducational groups. There were no major differences between the groups in any of the outcome measures at baseline (Kleffelgaard, 2018).

The baseline assessments were conducted 3.5 ± 2.1 (mean ± SD) months after injury. The first follow-up assessments were conducted at a mean of 2.7 ± 0.8 months after the baseline testing. The second follow-up assessments were conducted approximately two months after the end of the intervention at a mean of 4.4 ± 1.0 months after baseline testing. At baseline, the participants presented with a mix of vestibular, visual, and musculoskeletal clinical findings/characteristics (Kleffelgaard, 2018). The self-reported outcome measures indicated that the included participants had moderate dizziness-related disability and severe symptoms of dizziness. The participants also reported a considerable burden of post-concussion symptoms and psychological distress. The performance-based scores for balance and mobility were below population norms, indicating reduced balance when standing with eyes closed and reduced functioning and tempo in usual mobility task. At the first post-intervention follow-up, a statistically significant between-group mean difference was found in the respective primary and secondary outcome measures in favor of the intervention group (Kleffelgaard, 2018). At the second post-intervention follow-up, the between-group
differences were no longer statistically significant (Kleffelgaard, 2018). The intervention group maintained their level of improvement, while the control group improved over time in dizziness-related disability and mobility problems. No significant differences between the groups were found in any of the other outcomes at the two post-intervention follow-ups.

In addition to the usual multidisciplinary traumatic brain injury rehabilitation, improved dizziness-related disability and mobility in favor of the intervention group at the first post-intervention follow-up, the control group continued to improve and at the second post-intervention follow-up, they were at the same level as the intervention group. No differences between the groups were found on the severity of vertigo symptoms, post-concussion symptoms, psychological distress, and balance at the two follow-ups.

The results from this study support findings from other studies that indicate benefits of vestibular rehabilitation after traumatic brain injury. This indicated that the interventions speeded up the recovery and had a positive effect on dizziness-related disability. The findings reflect on the baseline measurements indicated in the table above. Although there were many beneficial effects of the vestibular rehabilitation intervention that were maintained in this study, no between-group differences were found at the second post-intervention follow-up. This shows that even further research is needed to explore whether the improvement in the intervention group would have continued if the intervention exceeded eight weeks, compared with the control group.

**Discussion**

The aim of this systematic review was to investigate the effectiveness of physical therapy exercise interventions in individuals who sustain a concussion. This review revealed that
exercise interventions addressed post-concussive symptoms. Overall, this review demonstrated decreased time to recovery and reduced post-concussion symptoms when patients receive active physical therapy interventions compared to its control group (Naess-Schmidt, 2022). As the two studies showed significant improvements and no significant adverse effects, this treatment approach is safe and effective and although, the vestibular rehabilitation on dizziness and balance problems in traumatic brain injury randomized controlled trial study demonstrated that it needed additional research in order to really show improvement it still revealed it decreased post-concussion symptoms.

Each intervention could be conducted by a physical therapist in their own ways. For sub symptom threshold aerobic exercises, physical therapists should instruct their patients to perform aerobic exercise, such as, the exercise bike or treadmill, in their preferred mode, at an intensity of 80-90% of the symptom threshold. As for GAIN, physical therapists will use multiple evidence-based strategies including prescribed exercise, cognitive behavioral therapy, and any advice needed for gradual return to life activities. Lastly, for vestibular rehabilitation, physical therapists can assess for visual stability, oculomotor function, standing balance, and much more and conduct exercises like eye and head movements, walking up and down a slope. Overall, physical therapists should incorporate physical activity interventions earlier to optimize post-concussion recovery.

Physical therapists should take into consideration when implementing the interventions is psychosocial and economic factors, patient’s overall health status, and adherence to the intervention program (APTA, 2023). When taking in theses factors during the
decision-making process, coordination, communication, and documentation is so important to be able to provide direct interventions for patients.

Limitations

Despite the novel observations, a few limitations of this review should be noted. One clinical trial was only carried out at a TBI outpatient clinic at the Department of Physical Medicine and Rehabilitation, Oslo University Hospital (OUH), the trauma referral centre in South-East Norway which makes it not have a variety of patients from different settings. Also, all studies included a smaller sample size. One study included 35 patients in each group making a total of 70 patients, another study stated they needed 96 participants to find significant improvement with an anticipated dropout rate of 20%, they recruited 120 participants meaning 60 in each group. This could result in larger effect sizes, decrease the power of the data, and be unrepresentative of the population. Lastly, the overall bias. As in the GAIN intervention study, the five clusters (consisting of the 17 municipalities) participating in the trial have different approaches to usual care for people with persistent PCS, and some municipalities may offer more to participants allocated to EUC than others. Expectation bias may affect the results.

Conclusion

The results of this systematic review indicated that there is evidence supporting the use of physical therapy exercise interventions. Using physical activity and physical therapy as early as a couple days following injury, is beneficial at decreasing post-concussion symptoms, allows for earlier return to play and shorter days to recovery when compared to traditional treatments such as physical and cognitive rest.
https://www.cognitivefxusa.com/blog/neuroplasticity-treatment-for-concussions


Hemming, K. (2022, February 11). When is the stepped wedge study a good study design choice?. National Institutes of Health.


https://journals.sagepub.com/doi/10.1177/0269215518791274


