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Effectiveness of vestibular rehabilitation therapy (VRT) after persistent dizziness following sport-related concussion: a systematic review of the literature

Abstract

Background: Vestibular Rehabilitation therapy (VRT) is an exercise-based treatment program designed to promote vestibular habituation, adaptation, and substitution. The goals of VRT are to enhance gaze stability, postural stability, and to improve activities of daily living. Dizziness and balance impairments are common following sport-related concussions; however, it is unclear how much impact VRT may have in the treatment for this population.

Purpose: To conduct a systematic review to verify the application and outcomes of VRT after sport-related concussion with persistent dizziness and to determine the effectiveness of the treatment for sport-related concussion.

Method: A systematic review of the following electronic databases was conducted: CINAHL Complete, PsycINFO, SPORTDiscus, Academic Search Complete, PUBMED, COCHRANE, and MEDLINE. The search ranged from January 2011 to April 2023.

Results: 248 articles were found based on the specific search criteria. From them, 105 were selected and 54 records screened. After applying the criteria of inclusion and exclusion, four articles remained for examination.

Conclusion: Vestibular rehabilitation therapy shows promise to improve dizziness and imbalance symptoms in those who have suffered sport-related concussions. As current return-to-play protocols do not account for adequate compensation of the vestibular system and may result in reinjury, vestibular rehabilitation may be able to assist the player's recovery time, and in turn prevent reinjury; however, due to limited evidence, further studies are necessary to confirm these findings.

Keywords: vestibular, dizziness, concussions, reinjury

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Abbreviations: VRT, Vestibular Rehabilitation therapy; SRC, sports-related concussion; TBI, traumatic brain injury; BPPV, benign paroxysmal vertigo; VOR, vestibulo-ocular reflex; CNS, central nervous system; RTP, return-to-play; DHI dizziness handicap inventory.

Introduction

Balance is a precursor to movement and requires the seamless integration of the somatosensory, visual, and vestibular systems. All three systems send signals of sensory information to the brain, which is then processed to assist with balance, both static and dynamic, which are controlled by adjusting motor output of each of these three systems. In turn, the body can maintain posture and gaze.[1,2] Depending on the sport performed, the postural control system may be taxed in many ways though balance is a general requirement for success as an athlete.[3]

A sports-related concussion (SRC) is a commonly acquired traumatic brain injury (TBI) that can negatively impact the postural control system, thus impacting an athletes' postural stability.[4,5] Concussions are typically a result of both biological and mechanical disturbances caused by a "direct blow to the head, face, neck, or elsewhere on the body with an impulsive force transmitted to the head".[6] The diagnosis is challenging due to a lack of structured definition and variation of clinical characteristics among players; however, individuals scoring higher with the post-concussion symptom scale scores are often those with undiagnosed concussions, leaving them more vulnerable for future concussions.[7]

It is estimated that 1.6 to 3.8 million sport- or recreational-related concussions occur annually.[8] Dizziness and vertigo occur in up to 75% of individuals diagnosed with TBI which may have secondary occurrences of benign paroxysmal vertigo (BPPV), vestibulo-ocular reflex (VOR) impairment, sensory organization impairment, visual motion sensitivity, balance dysfunction, cervicogenic dizziness, and exercise-induced dizziness.[9–12] Although central compensation of the central nervous system (CNS) may occur spontaneously through neurological changes within the cerebellum and brainstem, maladaptive strategies, prolonged recovery time, and incomplete recovery may be a result of delaying or foregoing VRT.[13]

Vestibular Rehabilitation Therapy (VRT) is an exercise-based treatment program designed to promote vestibular habituation, adaptation, and substitution. It is applied as therapy in several vestibular disorders.[14–17] VRT is designed to ameliorate symptoms of vertigo and/or dizziness, improve balance, improve quality of life, and restore gaze stability post vestibular insult.[2,14–17]

Current return-to-play (RTP) protocols focus on reducing post-concussion symptoms through periods of physical and cognitive

rest through 6 stages. Although medical clearance is expected within 7-10 days, recent research suggests that prolonged rest adversely affects the pathophysiology of concussion, delays onset of effective therapies, and may be detrimental to recovery.[6,18–20] A recent cross-sectional study found that although "educators are following recommended practices of teaching a multifaceted approach to concussion evaluation and management, there is a lack of instruction on the use of a stepwise return-to-play progression and emerging SRC management tools that evaluate vestibular and ocular-motor deficits".[20–22] Evaluation of neurocognitive status, such as memory and attention span, is recommended to be performed by comparing pre- and post-injury results of the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT).[22] Additionally, neuroimaging of athlete's post-concussion reveals changes in brain physiology beyond clinical symptom resolution; therefore, current protocols may result in premature RTP decisions for athletes with concussion, increasing risk of reinjury due to a poorly compensated vestibular system.[23]

Despite the high incidence of dizziness and balance dysfunction in sport related concussion, reports of vestibular and balance rehabilitation in the management of concussion are sparse. It is important to verify VRT as a tool that can be utilized to reintroduce an athlete to the field after persistent dizziness following sport-related concussion. Due to lack of evidence-based management procedures, the aim of this review is to summarize the existing data and to describe the use and effectiveness of vestibular rehabilitation therapy as treatment for sport-related concussions.

Methodology

This systematic review was guided by the principles of the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P).[24,25] Articles published from January 2011 to April 2023 were included due to the recent interest in this topic and to ensure current and relevant research and treatment outcomes. The following databases were utilized: Cumulative Index to Nursing and Allied Health Literature (CINAHL Complete), PsycINFO, SPORTDiscus, Academic Search Complete, PUBMED, Cochrane Central Register of Controlled Trials, and MEDLINE. Each database was searched simultaneously using EBSCOhost, a collection of all EBSCOhost databases.

Search process

The following search terms were used: (sports-related concussion OR sports-related TBI OR traumatic brain injury) AND (vestibular rehabilitation or vestibular therapy) NOT (military OR veteran). The titles of all the studies from each database were enumerated on an Excel table document to identify doubled publications.

The inclusion criteria were (1) athletes diagnosed with concussion; (2) original data applying vestibular rehabilitation; (3) reporting at least one outcome measure related to the efficacy of the treatment; (4) written in English, Portuguese, or Spanish. Studies were excluded if: (1) they were classified as literature or systematic reviews, expert opinions, or case reports; (2) does not include athletes with concussion; (3) applied vestibular rehabilitation in combination with other rehabilitative therapies/multimodal interventions (e.g., manual therapy, strength training, occupational tasks, counselling, or medication).

Screening

At the initial screening stage, studies were included or excluded based on titles and abstracts. Abstracts determined to be included in the literature review were retrieved, if needed. Each full-text article was carefully appraised at the second level screening process according to the inclusion and exclusion criteria. The data extraction procedure was not blind once all the manuscript information related to journal, institution, authors, study design, intervention, outcomes were evident.

Results

The systematic review's course is presented in Figure 1. The electronic database search yielded 105 records after duplicates were removed.

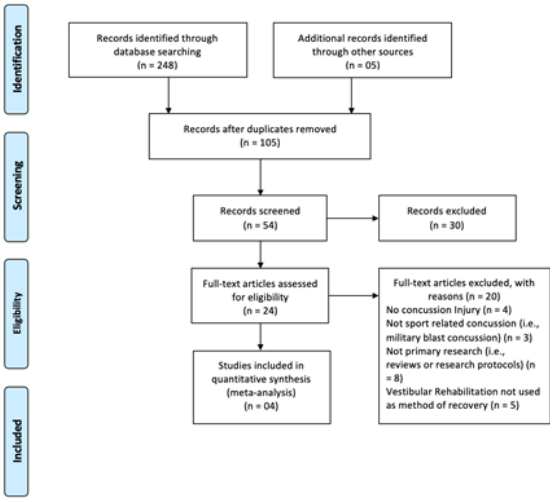

Figure 1 Results of the systematic review process.

The examination of titles and abstracts resulted in the retrieval of 24 full-text records. Following full-text review, 4 studies were included in qualitative analysis (Table 1). A fifth article meeting inclusion criteria was excluded due to the nature of possible duplication published in 2012 and 2014. Additionally, Kleffelgaard et al.[14] did not specifically tailor to sport-related concussion; however, this study had found no difference in vestibular rehabilitation outcomes between causes of injury at post-intervention follow-up. The quality analysis focused on whether each study had sample size justification, utilized a control group, randomized study participants, included an analysis of the results, and specifically stated inclusionary and exclusionary criteria. The current study also analyzes the level of evidence of included studies. The quality analysis revealed that four studies included sample size justification, three of which used a control group and randomized their study participants. Each of the five studies analyzed their results and listed inclusion and exclusionary criteria. Of the included articles, two of the articles were of level 2 of evidence, one study was level 3 of evidence, and one study was level 4 of evidence.

It was observed that all the studies conducted evaluated both genders. The sample size ranged from 42 to 50 subjects in two weeks to four months. The interventions focused primarily on improving balance. The focus on outcomes was effectiveness of vestibular rehabilitation. Exercise training interventions included participants walking on moving platform to evaluate posture, sway, and gait speed. Individuals were given differing tasks to complete, and they were multitasked during sessions to evaluate dual-tasking skills. Each study assessed different outcome measurements. Table 2 presents the summary of each article and their findings. This table includes the study's authors, year it was conducted, the participants included in it, its purpose, treatment and/or intervention, assessment and/or questionnaires used, and the main findings.

Citation: Pardue C, Michaels M, Felipe L. Effectiveness of vestibular rehabilitation therapy (VRT) after persistent dizziness following sport-related concussion: a systematic review of the literature. *J Otolaryngol ENT Res.* 2023;15(2):76–79. DOI: 10.15406/joentr.2023.15.00532

Note: *Activities-specific Balance Confidence scale (ABC), Mild traumatic brain injury (mTBI), sub-threshold physical activation (SPA), Post-Concussion Symptoms Scale (PCSS), Rivermead Post-Concussion Symptoms Questionnaire (RPCSQ), Dizziness Handicap Inventory (DHI), High-Level Mobility Assessment Tool (HLMAT), Hospital Anxiety and Depression Scale (HADS), Balance Error Scoring System (BESS), Vestibulo-ocular reflex (VOR), Post-Concussion Symptoms Scale (PCSS), Numerical Pain Rating Scale (NPRS), Neck Disability Index (NDI), Headache Disability Index (HDI), Activities-Specific Balance Confidence Scale (ABC), Sport related concussion (SRC), Cervical Flexor Endurance (CFE), Joint Position Error (JPE), Vertigo Symptom Scale (VSS), Sport Concussion Assessment Tool-2 (SCAT-2).*

Table 1 Quality analysis of studies for the literature review

Study	Sample size justification	Control group	Randomized	Analysis of results	Inclusion and exclusion criteria	Level of evidence
Kleffelgaard et al.[14]	Y	Y	Y	Y	Y	2
Schneider et al.[20]	Y	Y	Y	Y	Y	2
Alsalaheen et al.[15]	Y	N	N	Y	Y	3
Alsalaheen et al.[16]	N	N	N	Y	Y	4

Discussion

The vestibular system plays an important role in the regulation of balance, spatial orientation, and gaze stability. Dizziness and imbalance are the two most common early concussion symptoms following an athletic injury and/or head injury of non-athletic origin, occurring in 75% and 79% of patients, respectively.[29,30] According to several studies, damage to the vestibular system can exacerbate other concussion symptoms, proving to be a risk for extended recovery.[11,18,26–28]

As seen in this systematic review, a wide range of tools can be used to assess athletes' balance abilities post-concussion.[6,23,31] Currently, evaluation protocols are not standardized; therefore, the studies are unable to be directly compared to demonstrate effectiveness.[14–16,20] Recent consensus over concussion management suggests cognitive rest in the earlier phase (the first 24-48 hours), followed by a gradual return to activities, and most recently, the creation of protocols to actively target concussion rehabilitation has been explored.[6]

Vestibular rehabilitation therapy (VRT) utilized as a treatment option in cases of dizziness and imbalance post-concussion has been promising.[1–3] The aim of VRT is to encourage the plasticity of the patients' existing and partially intact neural systems by creating new neurological connections to bypass damage to the system that has occurred through injury.[14] There are three main categories of VRT: (a) habituation which involves continuous and progressive exposure to stimuli that provokes symptoms until the symptoms are no longer present with the presented stimuli; (b) adaptation which includes training the brain to rely on portions of the vestibular system which remain unaffected through various stimulating motions; and (c) substitution which includes saccadic strategy exercises to track objects with and without head movement in various planes to enhance the brain's reliance on the visual and somatosensory systems.[17,19] For the most effective treatment, patients should complete VRT with a trained clinician to ensure accuracy. The clinician's role will also include developing an individualized treatment plan by assessing the patient's capabilities at the beginning of treatment to avoid overstimulation while continuing to follow an established protocol.[3,15–18] Managing dizziness and imbalance through the use of vestibular rehabilitation post-concussion is part of emerging research and post-concussion syndrome is a significant topic in contemporary science.

When reviewing the studies used for this literature review, a lack of progression patterns and duration standardization is seen. With each of the 4 studies, none suggested recommended protocol, number of treatment sessions, or frequency.[14–16,20] Even though time was not specified, most symptoms seem to resolve from 6 to 12 weeks after beginning treatment according to each study's timeline. It is unclear whether faster recovery rates correlate with the duration of care or exercise type. Overall, in all four studies there is evidence that athletes suffering from post-concussion syndrome would likely benefit from VRT.[32,33]

A Cochrane review concluded that there is moderate to robust evidence of the success of vestibular rehabilitation for individuals with vestibular disorders, and regarding the current systematic review this may extend to individuals with vestibular disorders of athletic traumatic origin.[33–36] Evidence from the review of literature suggests that patients who experience symptoms of dizziness and/or imbalance should be referred to Vestibular Rehabilitation Therapy (VRT).

Limitations and future directions

More research is needed to definitively conclude whether vestibular rehabilitation is effective for athletes suffering from vestibular disorders of a traumatic origin. There is an absence of available randomized controlled trials or cross-sectional studies. Most of the data collected on this subject are retrospective or small cohort studies.

The lack of standardization of VRT protocol also proves to be a limitation. Although individualized treatment plans are important in targeting post-concussion symptoms, accurate research relies on standardization to verify effectiveness. In future studies, it would be beneficial to record the timeline from incident to implementation, results and subjective effectiveness of VRT that is capable of being quantified and compared such as with the dizziness handicap inventory (DHI), as well as a description of treatment progression and documentation of VRT exercises utilized. It is also important to include normative data for athletes with PCS regarding medical history, social/recreational activities, and demographics.

This study's aim was to understand vestibular rehabilitation benefits after a concussion; however, the results were limited due to the lack of a control group and the retrospective nature of the data accumulated. Due to different concussions needing different management techniques, a recommendation is to have a profile for each patient who sustained a concussion so that all the tests taken (subjective symptoms, neurocognition, and balance) can be all in one place and easily viewed. A multi-disciplinary approach is encouraged so that audiologists, neuropsychologists, physicians, athletic trainers, and physical therapists can share knowledge to best learn from and treat concussions.

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Conclusion

There is limited evidence of the efficiency of VRT in athletes after sustaining SRC. Current evidence shows promise in this population. Further studies on a higher level are needed to evaluate the effects of VRT in athletes who experience vestibular and/or balance dysfunction after a concussion.

Acknowledgments

None.

Conflicts of interest

The authors declare there are no conflicts of interest.

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