Sacred Heart University Scholar

Volume 1 | Number 1 Article 5

Fall 2017

Will Vestibulo-Ocular Reflex and Balance Rehabilitation Reduce Visual Deficits & Improve Stability of a Patient with Multiple Sclerosis?

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Will Vestibulo-Ocular Reflex and balance rehabilitation reduce visual deficits & improve stability of a patient with Multiple Sclerosis?

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ABSTRACT

Context. Identification of rehabilitation exercises to decrease symptomology in a patient with Multiple Sclerosis (MS) is necessary for enhancing quality of life. Various vestibulo-ocular reflex (VOR) rehabilitation exercises can help patients adapt to balance problems. Currently, no researcher has utilized the VSR™ Sport and *in*Vision™ systems by NeuroCom® for rehabilitation among patients with MS.

Objective. The purpose of the study was to create a rehabilitation protocol incorporating VOR and balance exercises to decrease visual deficits and improve stability in a patient with MS. This study will examine the effects of rehabilitation and determine if scores improve from baseline testing.

Design: Original Quantitative Research

Setting: Sacred Heart University Doctor's office

Patient: 40-year-old male with relapsing remitting Multiple Sclerosis (Height: 175.25cml; Weight: 72.5kg)

Interventions: One-hour VOR and balance rehabilitation sessions three days per week, for six weeks. The subject was baseline and post-tested using the VSR™ Sport and *inVision™* systems by NeuroCom®.

Main Outcome Measures: Data were collected using VSR™ Sport and *inVision™* systems by NeuroCom®. Baseline and post-test scores were compared and percent changes were calculated via Microsoft Excel.

Results: There was an overall improvement in scores for VOR and balance from pre- to post-tests. GST L increased by 60 percent from 98 to 157 deg/s, DVA L improved by 80 percent from 0.3 to 0.06 logMAR. LOS Mvmt Velocity L increased by 96% from 2.4 to 4.7 deg/s. SET sway velocity improved by 55 percent from 6.9 to 3.1 deg/s.

Conclusions: The six-week rehabilitation protocol using the NeuroCom® systems was effective in improving the subject's balance and VOR scores. A decrease in symptoms can improve the quality of life for a patient with MS.

Key words: Multiple sclerosis, VOR, Balance, VSR™ Sport, *inVision™*, NeuroCom®, rehabilitation

[1] We would like to Thank Dr. Theresa Miyashita for giving us the opportunity to work with the VSR™ Sport and *in*Vision™ systems, also to Sacred Heart University Athletic Training Program, which has provided us with the supplies, support, mentorship, and the ability to complete this project.

Introduction

Multiple sclerosis (MS) is a chronic autoimmune neurological disease of the central nervous system (CNS) that affects approximately 2.3 million individuals worldwide. Many patients experience episodes of potentially reversible neurological deficits, which are often followed by progressive neurological deterioration. Relapsing-remitting MS is the most common diagnosis affecting approximately 85 percent of MS patients, and is characterized by short terms of various symptoms followed by periods of remission.[2] The potential symptoms one may experience include but are not limited to: dizziness, vestibular dysfunction, fatigue, instability, decreased strength, and impaired cognition. There is currently no cure for an MS diagnosis, but visual, cognitive, and somatosensory rehabilitation and various medications are being used in an attempt to decrease symptomology and slow progression.[3]

Research has proved rehabilitation programs are effective, specifically in improving balance and VOR test scores in patients with MS.[4] Because all patients with MS present differently, each rehabilitation program is individualized for the needs of the patient based on their specific symptoms.[5] Various research has been done to show the effectiveness of vestibular rehabilitation in reducing dizziness, improving gait, and balance function in post-concussion patients.[6] These patients are comparable to those with MS due to similar CNS and vestibular disruption. Research results also suggest VOR rehabilitation is beneficial for a patient experiencing vestibular dysfunction and instability.[7] Improving instability and gait in this patient may also serve to decrease other deficits such as muscle strength, tremors, and fatigue.[8]

The patient participating in this study was diagnosed with relapsing-remitting MS and experiences visual and balance deficits on his left side. There is limited research on a rehabilitation program specifically combining the effects of both VOR and balance training on a single patient with MS. The purpose of the study was to create a rehabilitation protocol incorporating VOR and balance exercises to decrease visual deficits and improve stability in a patient with MS. This study will examine the effects of rehabilitation and determine if scores improve from baseline testing.

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Methods

Participants. One 40-year-old male with relapsing remitting MS (height: 175.25 cm weight: 72.5 kg) participated in this study. The subject had not participated in any rehabilitation related to MS since his diagnosis but is extremely active and maintains a healthy lifestyle. The subject administers three 40mg injections of Copaxone per week prescribed by his doctor.

Instrumentation. Pre- and post-test data were collected using the VSR™ Sport and *inVision™* systems by NeuroCom® (Clackamas, OR). The testing screen was 1.1m off the ground and the participant's eyes were 2.13m from the screen specifically for VOR rehabilitation, and the force plate was 1.1m from the screen for balance exercises. VOR was assessed using *inVision™* system to measure: perception time (PTT), static visual acuity, gaze stabilization (GST), and Dynamic Visual Acuity (DVA). These tests require the patient to move his head to a fixed velocity while keeping his eyes on a fixed optotype on the screen. The ability to maintain the determined velocity and amount of errors recalling the direction of the optotype on the screen were measured by the researchers. The subject wore a calibrated head accelerometer provided by the *inVision™* system to measure head velocity and degree of head movement.

The subject's instability was assessed using VSR™ Sport System tests: limits of Stability (LOS), which required the subject to control his center of gravity by shifting his weight to specified points on the force plate and Stability Evaluation Test (SET), which is similar to the Balance Error Scoring System completed in the Sport Concussion Assessment Tool. The subject completed these tests standing on a force plate and high-density foam, provided by the VSR™ Sport system, to measure his center of gravity and sway velocity.

Procedures and Data Collection

Prior to the start of the study, the subject signed an informed consent form approved by the University's Institutional Review Board. Prior to the six-week rehabilitation program, the patient completed a VOR and balance baseline test. Both examiners were present for the baseline test. The participant completed the baseline tests in the following order: PTT, GST, DVA, SET, and LOS. The rehabilitation program was divided into three sessions per week and performed in the same order each week (VOR, balance, and VOR and balance). The sessions took place at 7am on Monday, Wednesday, and Friday for six consecutive weeks. The exercises remained the same each session unless difficulty was increased or additional exercises were added (Figure 1, Table 2). The subject was not participating in any other rehabilitation training but had been running at least 3x per week prior to the start of the six-week program.

The *inVision™* system is pre-programmed with levels of difficulty for each background type including: color, stripes, checkers, and falling objects. The examiner manipulated the target head velocity, size of optotype, and metronome pace. The patient calibrated the accelerometer before each trial and was given a practice trial before each assessment. Before and after each trial, the patient was asked to rate any occurring symptoms on a scale from zero-ten including:

dizziness, nausea, eye pain, headache, or fogginess. During each trial, the optotype "E" appeared on the testing screen in different directions (left, right, up, down). The patient recited what he saw on the screen and the same examiner recorded it on the provided remote for each session. The variables changed in difficulty based on the progress of the patient (Figure1). The subject's progression included background change, decreased optotype size, and increased metronome to pace his head velocity. The system measured average head velocity, optotype size, compliance, and the percent of average head symmetry for each trial.

The VSR™ Sport System provided the option to choose a sequence training program or a custom training program for the examiner to manipulate. The pre-programmed baseline test measured the patient's stationary double leg and single leg stability, and double leg stability while shifting center of gravity, on various surfaces (*i.e*. firm, foam). The sequence-training program allowed the examiner to choose which joint to focus each rehabilitation exercise on, including ankle, knee, hip, and lumbar spine. Each joint category had levels based on weight bearing status, level of stability, and exercise difficulty. The patient started each category on level three and progressed by weight bearing status, pace time, and surface type (Figure 2). Prior to each trial, the patient was able to practice the exercise. Left- and right-side weight shifts and single leg exercises lasted for one minute and double leg center of gravity exercises lasted for two minutes. Center of gravity control and the core were exercised with the lumbar stability test using a weighted medicine ball that increased in weight each week. The protocol consisted of different exercises requiring the subject to shift his weight to specific targets, or maintain balance for a period of time. Toward the end of the protocol, the examiner manipulated the pace time and position targets using the custom training sequence. As the patient's performance improved, the rehabilitation protocol progressed. The system measured compliance and pace time for each trial.

All exercises during the VOR and balance rehabilitation protocol differed from assessments in the baseline test and post-test. After the six weeks of VOR and balance rehabilitation, the subject was then post-tested utilizing the same baseline test.

Statistical Analysis

SPSS was not used to run stats because there was only one subject and no other data points to compare the results to. The results from the pre- and post-rehabilitation tests were entered into a Microsoft Excel spreadsheet. Percent changes between the pre- and post-test scores for both VOR and balance were calculated.

Results

The patient had an overall improvement in VOR scores between pre- and post-test scores (Table 1). From pre- to post-test the patient achieved the best possible score of 20ms for PTT. GST had a bilateral increase in achieved average head velocity from pre- to post-test with a 44.6 percent increase on the right from 121 to 175 deg/s and a 60 percent increase on the left from 98 to 157 deg/s. The patient improved from favoring his right side by 11 percent to favoring the impaired left side by 5 percent. PTT, GST, DVA percent changes are highlighted in Table 1.

Balance pre- and post-test score improvements are highlighted in Table 2. LOS forward reaction time improved from 1.13 seconds to 0.49 seconds. Forward movement velocity improved from 1.9 deg/sec to 4.7 deg/sec and to the right from 2 deg/sec to 6.8 deg/sec. Sway velocity decreased on tandem foam from 10.9 to 4.1 deg/sec. A majority of the scores improved on the stability evaluation test (Figure 3).

Discussion

Our subject was diagnosed with relapsing-remitting MS in 2003, and continues to have relapsing symptoms, specifically vision (blinders) and balance deficits, on his left side. The subject is aware of deficits in his fine motor skills and balance when performing activities of daily living (ADLs) and work-related tasks. An effective rehabilitation program for MS requires acknowledgement of patient's potential impairments.[9] The patient was compliant throughout the protocol and honest about his symptoms. Patients with MS depend strongly on vision for balance control mostly because of proprioceptive and vestibular deficits.[10] This rehabilitation protocol combines VOR and proprioceptive exercises to potentially provide increased stability, coordination within motor functions, and higher quality of life among a patient with MS.

VOR is a reflex used to stabilize gaze, which provides a stable environment for retinal focus.[11] As an individual ages, his or her VOR is increasingly impaired and negatively effects their perception of balance.[12] VOR has been rehabilitated to achieve normal function in many neurodegenerative diseases such as Parkinson's and progressive Supranuclear Palsy.[13] There is no research using the *inVision™* system for VOR rehabilitation on patients with MS, but similar symptoms from head-induced trauma have decreased from these VOR interactive exercises.[14] According to Cohen, it is necessary to incorporate VOR therapy and rehabilitation programs for patients who are experiencing balance deficits.[15] Balance is the second-most-common symptom

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associated with MS, and one of the most disruptive symptom in patients' lives.[16] Davide Cattaneo found patients with MS have difficulty maintaining balance with a reduced base of support, specifically when dynamically transferring their center of mass and when sensory input is disturbed.[17] As seen in the results the subject had a bilateral improvement in head velocity during GST and in movement velocity from right to left during LOS. The somatosensory system allows for proprioceptive function to work with vision and balance. It is necessary to also train balance in conjunction with VOR, as both of these systems work together with one another during ADLs.[18] In our study, the scores of both VOR and balance improved throughout the protocol. Post-test VOR scores have a greater increase from baseline than balance scores.

Exergaming is a term used for videogames that are also used as a form of exercise. Researchers believe playing exergames on an unstable surface, such as foam, appears to be an effective way to improve balance and gait in patients with MS.[19] The integration of exergames has a positive effect on adherence and is thus potentially beneficial for the long-term effectiveness of rehabilitation programs. The VSR™ Sport System is comparable to exergaming because of the computer-based exercises and the subject's ability to follow their movements on a given surface and on the screen provided.

The patient has not partaken in any previous rehabilitation programs for his symptoms. Our results indicate the combination of VOR and balance rehabilitation has a positive effect on a patient with MS experiencing these specific symptoms. Using the systems provided by NeuroCom® is an effective way to maintain the patient's adherence and utilize practical balance and VOR exercises. The results show that this protocol is able to increase his stability and VOR during these assessments. The patient did not report a noticeable difference after the rehabilitation protocol but did not experience symptoms before, during, or after the six weeks.

Further research should compare the effects of a similar rehabilitation protocol on multiple patients suffering from various symptoms. The progression in this protocol was based on the patient's ability to perform and therefore can vary among other patients. SET tandem firm was the only assessment that did not have a positive improvement. This could be possible because of the patient's frustration during the assessment causing him to fall off of the firm surface. Patients' behaviors throughout the protocols should be considered when progressing the exercises. Uplifting music was added to the balance rehabilitation sessions to help with the patient's frustration and adherence but was not used during pre- or post-tests.

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Rehabilitation is designed to prevent complications and minimize functional deterioration. Vestibular rehabilitation attempts to help patients adapt to balance problems.[20] Many researchers have analyzed the correlation between VOR rehabilitation for MS patients and balance rehabilitation for MS patients. No researchers have used the NeuroCom® systems to rehabilitate patients with MS. This six-week rehabilitation program was successful at improving scores from pre- to post-test; however, we are unable to determine if these findings have a statistical significance.

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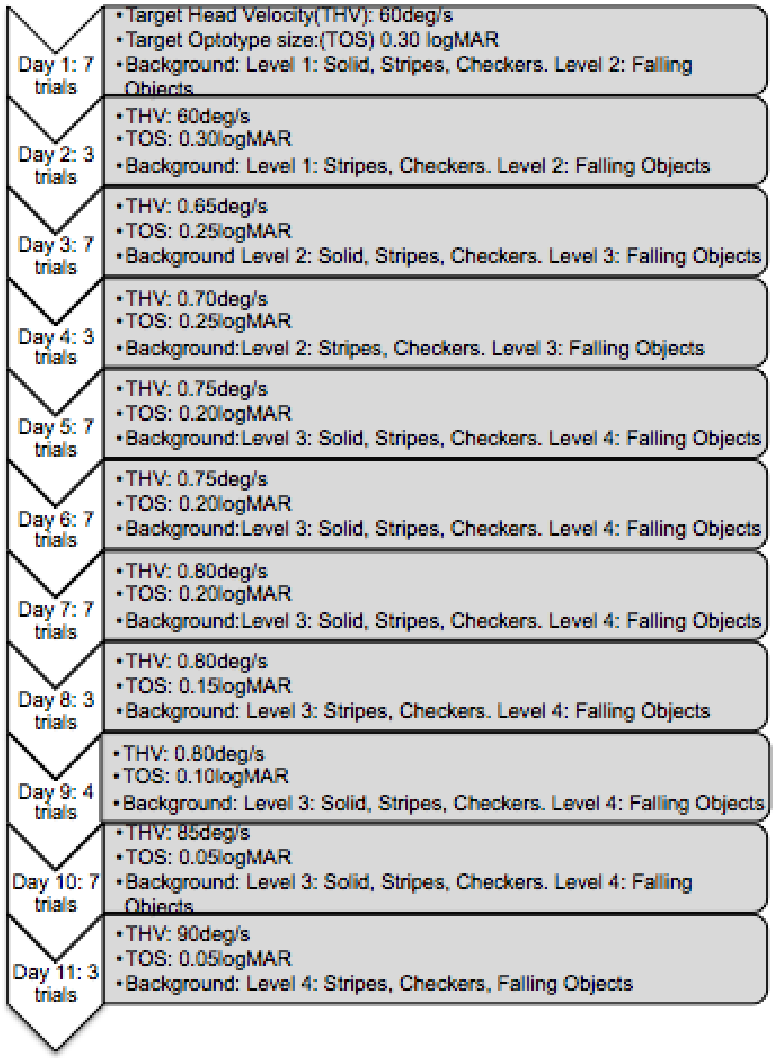

FIGURE 1. VOR Rehabilitation Protocol via NeuroCom® InVision System

FIGURE 3. Stability Evaluation Test pre- and post-test results