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Case Report

The Management of Balance and Proprioception Discrepancies for a Patient with Cervicogenic Headache: A Case Report

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Abstract

Introduction: *Previous research studies have established a link between cervical dysfunction, proprioception, and balance deficits in patients with cervicogenic headache. However, no current research exists to determine if the implementation of a balance program for these patients has any effect on their balance and proprioception capabilities. This case study aimed to identify if significant changes can be made the overall balance of a patient with cervicogenic headache as measured by the NeuroCom Sensory Organization Test.*

Case Description: *The patient was a 50-year-old female, who had been suffering from long term cervicogenic headaches with increasing frequency and intensity for 6 months.*

Outcomes: *The patient was seen for six visits over six weeks for balance training in addition to traditional physical therapy interventions including manual therapy and therapeutic exercise. After 6 sessions the patient made an overall improvement in balance (+7.9%) measured via the NeuroCom Sensory Organization Test and clinically significant improvements in reported pain via the Headache Disability Index (91.6%), Neck Disability Index (63.6%) and the Visual Analog Scale (2.5 points).*

Discussion: *This case report demonstrates when balance training is added to standard manual therapy interventions for the management of cervicogenic headache you can successfully improve overall balance control measured with the NeuroCom Sensory Organization Test. Further research is necessary to further validate balance programming as a key intervention strategy for the general population with cervicogenic headache and guide decision-making for these patients.*

Introduction

Over half of the world's population experiences headaches within their lifetime, making headaches a significant burden on society [1]. Millions of days and billions of dollars are lost each year in the workplace due to sick days or missed work from headaches [1]. Cervicogenic headaches (CEH) are secondary headaches related to a cervical disorder or neck pain [2]. CEH are found in up to 18% of the chronic headache population and tend to start earlier in life around ages 32-35 [1, 3]. The clinical diagnostic criteria for CEH was developed by the Cervicogenic Headache International Study Group (CHISG) and includes unilaterality of pain varying in frequency and duration, however it has also been reported that CEH could also present bilaterally [3, 4]. The CHISG report that subjects with CEH present with restrictions in range of motion in the neck or that the CEH is the result of sustained awkward neck positions.4 Upon physical elevation there is typically provocation of head pain with external pressure over upper cervical or occipital region on the symptomatic side, and ipsilateral neck, shoulder, or arm pain [4]. The CEH presentation typically varies in frequency and duration. It has been reported that patients may also report non-specific posterior cervical pain [3].

The posterior suboccipital muscles are innervated by the C1 spinal nerve and the C2-3 ventral rami innervate the prevertebral muscles of the cervical spine [5, 6]. The dorsal rami of C1-3 supply innervation to the atlantoaxial joint and its ligaments, the posterior cranial fossa and dura mater, trapezius, and sternocleidomastoid [5]. The dorsal rami of C2 innervates the splenius capitis and semispinalis capitis muscles, while dorsal rami C3 supplies splenius capitis and cervicis. The C2-3 zygapophyseal joint and intervertebral disc are also supplied by the C3 spinal nerve [5]. Spinal nerves below the C3 level have no referral to the structures of the head and therefore would not be implicated in CEH [4, 6]. Based on innervation patterns in the upper cervical region it has been hypothesized that referred pain to the head is the result of nociceptive afferent stimulation converging on the trigeminal nerve in the trigeminal nucleus caudalis [4]. Additionally, the frontotemporal distribution of the pain is the result of stimulation of the ophthalmic branch of the trigeminal nerve [7].

Studies have shown that cervical dysfunction leads to a change in proprioception [8-10]. Proprioception is the body's sense of awareness regarding joint position and movement [8]. Mechanoreceptors are specialized nerve endings responsible for proprioception. It has been demonstrated that the suboccipital muscles and other posterior cervical muscles have an abundance of muscle spindles [8, 11]. Compared to other musculature in the human body the dorsal neck muscles have an abundantly high content and density of muscle spindles [11]. Kulkarni et al demonstrated that the importance of the suboccipital muscles in maintaining cervical joint position, movement, and overall proprioception due to their intense concentration of muscle spindles. Other dorsal neck muscles such as the upper trapezius, splenius capitis, and splenius cervicis have also to be shown to possess high spindle content as well. Therefore, dysfunction in the upper cervical spine resulting in pain, swelling, and/or fatigue of these muscles can severely impact the proprioceptive abilities of these muscles [8].

There is a link between proprioceptive afferent information and the ability to maintain body posture and good balance [12]. Studies have shown that patients with neck pain have reduced proprioceptive abilities and balance training can improve deficits in proprioception and balance [9-14]. Though there is research detailing the efficacy of balance training programs for cervicogenic dizziness, there is no current literature addressing the addition of a balance program to traditional physical therapy treatment for patients with cervicogenic headache and/or neck pain. There have been studies as previously mentioned that determined proprioceptive training improves deficits of proprioception and balance in individuals, but this information has not thus far been applied to individuals diagnosed with cervicogenic headache. Therefore, the aim of this case study was to identify if balance training in addition to standard physical therapy had an impact on the balance, postural control, and overall quality of life in a patient with CEH.

Case Description
The subject was a 50-year-old female with a history of headaches presenting with an insidious increase in frequency and intensity over the past 6 months. She was referred for physical therapy by a neurologist, with the diagnosis of neck pain and cervicogenic headaches. The patient reported headaches starting from the right eye and radiating around the head to the occiput with occasional pain radiating from the neck into the right shoulder. The patient described the headaches occurring approximately five times per month and having an intensity that restricted her functional activities and participation in daily activities. The patient also reported that if present she usually woke up with a headache. She has tried to keep time charts to watch for patterns of when the headaches occurred, but no pattern was identified, and they seemed random. The patient was screened for yellow and red flags to determine if she was appropriate for physical therapy intervention and none were detected. Based on the patient's complaint and presentation during the initial examination it was determined that she was most likely suffering from cervicogenic headaches and would be an appropriate candidate for physical therapy assessment.

Patient Examination
Outcome Measures
The patient completed the Headache Disability Index (HDI), Neck Disability Index (NDI), and the Visual Analog Scale (VAS). The aim of the questionnaires was to gain quantitative data regarding the subject's condition and how it affected her daily life. The HDI has very good reliability values ranging from 0.93-0.95 and the NDI has a great test-retest reliability score of 0.96 [15-17]. The HDI was developed to quantify the impact of headache on daily living. The self-report questionnaire consists of 25 items requiring a yes scored as 4 points, sometimes which is scored as 2 points, or a no scored as 0 points. The patient's initial score was 72. The maximum score for the HDI is 100 points and the lowest score possible is 0 points [18]. The NDI is a 10 item self-report questionnaire used to measure the level of perceived disability secondary to the patient's neck pain. Each item is measured on a scale from 0 (no disability) to 5 with a maximum raw score of 50. The test score can then be multiplied by 2 to get a percentage score out of 100. The minimum clinically important difference for the NDI is 5 points or 10% [19]. The Visual Analog Scale (VAS) was used over the course of the study to quantify the patient's pain level. The scale starts on the left (score of zero) "no pain at all" and is 10 centimeters long; the right side indicates the "worst pain imaginable" (score of 100) [20]. The score is determined by measuring the distance from the starting point of 0 to where the subject placed their mark and measured in millimeters. The VAS has good construct validity and test-retest reliability ($r=0.94$, $p<0.001$). The minimum clinically important difference (MCID) of the VAS is 1.37 [20].

Postural assessment demonstrated right shoulder elevation compared to left, forward head posture with protracted shoulders, and bilateral scapular winging. Cervical Range of Motion (ROM) was measured in flexion, extension, lateral flexion, and rotation using a single inclinometer. The inclinometer was placed on the subject's head. Cervical rotation was measured in the supine position. Single inclinometry has high inter-tester reliability: $r= 0.92$ in flexion, $r=0.91$ in extension, $r=0.93$ in right lateral flexion, $r=0.92$ in left lateral flexion, and $r=0.91$ in rotation [21]. The patient's cervical active range of motion for flexion was 52 degrees, extension was 69 degrees, right rotation was 61 with right cervical tightness, left rotation was 78 degrees, right lateral flexion was 40 degrees, and left lateral flexion was 33 degrees with right cervical tension. To identify upper cervical rotation deficits the Flexion Rotation Test (FRT) was used, which has a sensitivity of 0.91 and specificity of 0.90 [21]. During the FRT only C1-C2 rotational movements are assessed [21]. Both right and left rotation was measured at 45 degrees bilaterally. Shoulder active range of motion was within normal limits as tested through an upper extremity generalized motion screen. The upper extremity ROM screen included functional tasks such as ability to reach behind the back and neck, ability to raise extended arms overhead and out from sides to overhead, and the ability to touch the head. Based on her ability to perform these tasks the upper extremity ROM was considered within functional limits. Deep neck flexor endurance was tested because weak deep neck flexors are a common contributing factor to CEH and neck pain [22]. The Neck Flexor Muscular Endurance Test (NFMET) was used. During the test, the subject's head is lifted with slight chin tuck, which is marked as neutral by the clinician. The subject is asked to hold that position for as long as possible, the test is concluded once the patient's head moves 5 degrees from the neutral point. This method of assessing cervical strength has high inter-rater reliability (ICC=0.96) [23, 24]. The NFMET for this subject was measured at 3 seconds with poor activation and indicative of decreased endurance of the deep neck flexors whereas the average time for women is 29.4 seconds [25]. Manual muscle testing of the rhomboids, middle and lower trapezius revealed muscle weakness and was equal bilaterally graded at 4-/5. Upper extremity myotomes and neurological screening were negative. Passive intervertebral motion testing with posterior-anterior glides demonstrated hypomobility at the C2-3, C5-7, and T3-9 segments. Special testing included a negative compression/distraction test and a negative Spurling's test.

Balance Assessment:

The patient's balance was assessed using the Neurocom Sensory Organization Test (SOT) (Figure 1). The SOT detects weight shifting and postural changes while standing and correlates this with balance and vision [15]. The SOT assesses the ability to effectively use visual, proprioceptive, and vestibular inputs and the ability to suppress inaccurate sensory data by analyzing the amount of body sway under different sensory conditions [15]. The sensitivity and specificity of the SOT for balance impairment detection is 0.85 and 0.77 respectively [16, 17]. The test-retest reliability stands between 0.67 and 0.90 for each stage of the test indicating fair to good reliability [26, 27]. The SOT may also be used for measuring dynamic balance [27, 28]. The standard measurement protocol for the NeuroCom SOT includes six different stages, which gradually increase the challenge to the balance systems. In the first stage the subject maintained their balance with their eyes open, without any movement of either the baseboard or the cage. Stage two challenged the static balance by eliminating visual input thought the closure of the eyes. In stage three, the subject stood with eyes open and simultaneous movements of the cage surrounding them. The fourth stage the subject was required to maintain her balance with their eyes open while undergoing disruptive movements of the baseboard. In stage five the subject's eyes were closed and standing balance was challenged by disruptive movements of the baseboard. In stage six, the subject stood with their eyes open and was exposed to movements of both the baseboard and the cage.

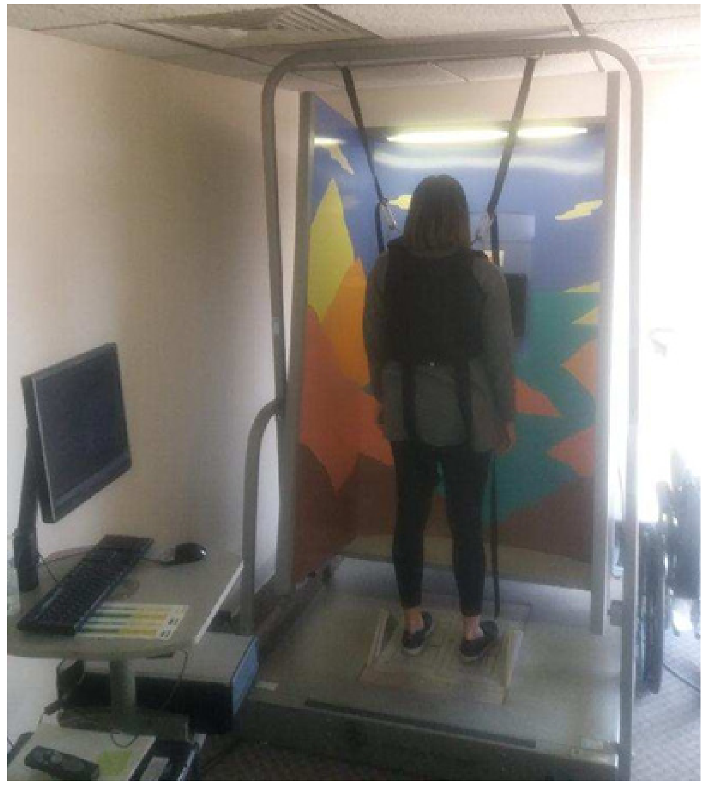

Figure 1: NeuroCom with example subject

To obtain a measure of postural control, the collective composite score was used, which is a composite score of the subject's performance at each of the six stage of the test. A composite score of less than 38 indicates impaired control and a high risk for falls [29]. Two trials were performed for each of the six stages and the result can be found in (Table 1).

TABLE 1: Outcome Scores

Assessment	Initial Evaluation/ Session 1	Session 3	Session 5	Discharge/ Session 6	Overall Change
HDI	72	38	12	6	-91.6%, -66 points (MDIC= 29 points)
NDI	22	10	14	8	-63.6%, -14 points (MDIC= 5 points or 10%)
VAS	3.5	9.0	4.0	1.0	-2.5 points (MDIC= 1.37 points)
NeuroCom composite stage 1 Average	96.5	96	95	94	-2.6%
NeuroCom composite stage 2 Average	91.5	94	91	91.5	0%
NeuroCom composite stage 3 Average	87	94.5	93	89.5	+2.9%
NeuroCom composite stage 4 Average	72.5	87	90	93	+28.3%
NeuroCom composite stage 5 Average	59.5	73	49.5	55.5	-6.7%
NeuroCom composite stage 6 Average	68	83.5	46.5	81.5	+19.9%
SOT	76	87	74	82	+7.9%
Cervical Flexion	47	55	63	64	+17˚
Cervical Extension	51	69	75	65	+14˚
Cervical Lateral Flexion Right	39	40	46	50	+11˚
Cervical Lateral Flexion Left	39	33	44	53	+14˚
Cervical Rotation Right	55	61	66	71	+16˚
Cervical Rotation Left	50	78	71	71	+21˚
NFMET	8	3	8	15 (Female Avg=29.4s)	+7 seconds
FRT Right	45	57	57	60	+15˚
FRT Left	45	57	57	61	+16˚

Patient Assessment

Based on the examination findings it was determined that this subject was appropriate for physical therapy treatment. This decision was based on the lack of presence of red or yellow flags, higher scores on the NDI, HDI, and VAS indicating limitations in function and participation, impaired posture, impaired ROM, and decreased deep neck flexor strength and endurance. The subject appeared to be a good candidate for the inclusion of balance activities based on the results of the NeuroCom SOT, and the understanding that subjects with cervicogenic headache and neck pain often exhibit decreased proprioception and balance. The patient was seen once a week for 6 weeks for skilled physical therapy due to low complexity and limitations in the patient's personal schedule. Treatments would include therapeutic exercise for strength and endurance, manual therapy for pain relief and muscle relaxation, and balance exercises.

Intervention

Based on the results of the examination, the patient's initial treatment was focused on manual therapy to her cervical and thoracic spine (Table 2). Manual therapy treatment for this patient included myofascial release and soft tissue massage of the cervical paraspinals, suboccipitals, levator scapulae, bilateral upper trapezius, and interscapular area. Thoracic manipulations were performed at the T3-9 segments at Maitland's grade 3-4 and twice times at a Maitland grade 5 thrust manipulation at the T3-4 segment. Studies have shown that thoracic manipulation has positive effects for patients with neck pain and/or neck pain with headaches in reducing pain, improving dysfunction and posture, and increasing neck ROM [30, 31]. Additionally, suboccipital releases and left rotational Sustained Natural Apophyseal Glide (SNAG) targeting C5-6, C6-7 segments for increased range of motion were performed as well. SNAGs have been shown to be a safe and effective treatment method for cervicogenic pain that has an efficacy in reducing pain and disability caused by cervical ROM limitations and disfunction [32]. The subject underwent dry needling with one 1-inch needle targeting the insertion of the following muscles: the right levator scapulae, right mid upper trapezius, and right C5-6 C6-7 paraspinals. Dry needling to the cervical paraspinals, suboccipitals, and upper trapezius both superficially and deep have shown to improve scores on the HDI, trigger point tenderness report, functional rating, and ROM in patients with cervicogenic headache, migraine, and neck pain [33, 34]. During the first session the patient's therapeutic exercise consisted of upper trapezius, suboccipitals, and levator scapulae stretching, chin tucks, chin tuck with alternating arm flexion, scapular retraction, and scapular retraction exercises in a door frame. Ten minutes of balance activities completed the first session. The subject used a cervical laser pointer in narrow stance to challenge balance as part of the phase 1 of the balance program used in this case. The subject was provided a home exercise program consisting of five balance activities the clinician requested her to perform for 5 minutes per day when not in the clinic when not seen in the clinic and this program was updated based on the balance training stage after each visit.

Table 2: Therapeutic Interventions Performed Each Session

	Session 1	**Session 2**	**Session 3**	**Session 4**	**Session 5**	**Session 6 Discharge**
Manual Therapy	STM/MFR Upper trapezius (UT), cervical paraspinals (CP), suboccipital, levator scapulae (LS), interscapular area Suboccipital release Right UT trigger point release	STM/MFR of UT, LS, suboccipitals, interscapular area, CPs Suboccipital release Thoracic PA glides grade 3 T3-9 Grade 5 manipulation T6-7	STM/MFR of UT, LS, suboccipitals, interscapular area, CPs Suboccipital release Thoracic PA glides grade 3 T3-9 Grade 5 manipulation T6-7 SNAG C5-6 L rotation	STM/MFR of UT, LS, suboccipitals, interscapular area, CPs Right LS trigger point release SNAG C5-6 and C6-7 L rotation Dry needling Right LS, Right mid UT, and Right C5-6 and C6-7 CPs	STM/MFR of UT, LS, suboccipitals, interscapular area, CPs Suboccipital release	STM/MFR of UT, LS, suboccipitals, interscapular area, CPs Suboccipital release Grade 4 manipulation T6-8
Therapeutic exercise	UT, LS, and suboccipital, stretching Chin tuck w/ and w/o alt UE flexion Scapular retraction Door frame Y/Ts	UT, LS, and suboccipital, stretching Chin tuck w/ alt UE flexion Prone Y/Ts Prone cervical retraction	UT, LS, and suboccipital, stretching Chin tuck w/ alt UE flexion Prone Y/Ts	UT and LS stretching Chin tuck w/ alt UE flexion Scapular retraction	None	Mid Trapezius, LS, and suboccipital, stretching Chin tucks against wall w/ alt UE flexion Scapular retraction Wall shoulder Ws Prone Y/Ts Serratus anterior wall push up

Balance activity	Cervical laser tracing, narrow stance on firm surface NeuroCom test	Cervical laser tracing in tandem on firm surface	Cervical laser tracing in tandem stance on foam NeuroCom test	Cervical laser tracing in narrow stance, foam pad, superimposed UE motion	NeuroCom test	Cervical laser tracing, marching on foam NeuroCom test

The second treatment consisted of manual therapy including myofascial techniques targeting the upper trapezius, cervical paraspinals, suboccipitals, levator scapulae, and interscapular area. She underwent a suboccipital release, and thoracic posterior-anterior glides grade 3 to the T3-9 segments and a grade 5 manipulation to T6-7 segment. She participated in therapeutic exercises including chin tuck with alternating arm flexion and prone scapular retraction strengthening. She underwent stretching with 30 second holds of the upper trapezius, levator scapulae, and suboccipital muscles. Balance training consisted of 5 minutes cervical stabilization tracing with a laser pointer in tandem stance following phase 1 of the balance program. After this the subject advanced from narrow to tandem stance activities as she had demonstrated minimal sway or loss of balance and reported minimal challenge in the narrow stance position.

During the third visit she received manual therapy including myofascial techniques targeting the upper trapezius, cervical paraspinals, suboccipital muscles, levator scapulae, and interscapular region. After this she underwent a suboccipital release. She received joint manipulation with thoracic PA's grade 3 to T2-9 segments, a grade 5 manipulation to the T6-7 segment, and SNAG of C5-6 into left rotation. Therapeutic exercise consisted of chin tucks with alternating arm flexion, upper trapezius, levator scapulae, and suboccipital stretching, and prone scapular retraction strengthening. Balance exercise included the re-assessment on the NeuroCom SOT and 5 minutes of cervical stabilization/laser tracing in tandem stance on foam. The patient had reported minimal difficulty with tandem stance on a firm surface and demonstrated minimal to no sway when performing the activity and was progressed to a foam surface which provided more of a challenge on this date. During the fourth treatment she received manual therapy myofascial techniques targeting the upper trapezius, cervical paraspinals, suboccipitals, interscapular area, and levator scapulae with an R side levator scapulae trigger point release she underwent a SNAG into L rotation for C5-6 and C6-7. Dry needling was also performed using 1-inch needles to right levator scapulae, right mid upper trapezius, and right C5-6 and C6-7 paraspinals. Therapeutic exercise included chin tucks with alternating arms, upper trapezius and levator scapulae stretching, and scapular retraction. Balance training consisted of the patient advancing to cervical stabilization/laser tracing standing in a narrow stance on the foam pad with superimposed upper extremity movements. On this date the patient was progressed to phase 2 of the balance program due to ability to maintain upright position with minimal difficulty reported and perceived by the clinician with the phase 1 activities.

During the fifth treatment session the patient was seen by another clinician and no therapeutic exercise or balance activities were performed this session and treatment was focused on manual therapy interventions only with the instruction to continue her home exercise program. The patient was assessed on the NeuroCom SOT during this session. Manual therapy included myofascial techniques targeting the upper trapezius, the cervical paraspinals, the suboccipitals, and the levator scapulae, and the interscapular area. She underwent a suboccipital release. The final sixth treatment included myofascial techniques targeting the upper trapezius, the cervical paraspinals, the suboccipital muscles, the levator scapulae, and the interscapular area. She underwent a suboccipital release and received a grade 4 manipulation to T6-8 segments. Therapeutic exercise consisted of scapular retractions, chin ticks against a wall with alternating arm raise, and serratus anterior wall push-ups. She underwent suboccipital, levator scapulae, and middle trapezius stretching. Her balance exercises consisted of cervical stabilization/laser tracing while marching on a foam pad and a NeuroCom balance assessment. The decision to progress the patient to phase 3 of the balance activities was due to patient report and demonstration of minimal challenge to balance with phase 2 activities.

Outcomes

Our subject filled out the HDI and NDI questionnaires during the initial evaluation, during week 3 of treatment, and at discharge from therapy services. Table 1 demonstrates an overall increase in cervical range of motion for all available motions in the cervical spine including flexion, extension, bilateral lateral flexion, and bilateral rotation. The subjects's FRT scores indicates that she made gains in her upper cervical range of 15 degrees to the right and 16 degrees compared to baseline. The subject demonstrated significant improvement in her HDI scores. For changes in score of the HDI to be considered clinically significant, a minimum 29-point change or greater in the total score from test to retest must occur allowing the change to be attributed to treatment effects [18]. As shown in Table 1, the subject had a 66-point decrease in score at discharge. The HDI separates potential scores into four categories: 10-28 points indicates mild disability, 30-48 points indicates moderate disability, 50-68 points indicates severe disability, and 72 or more points indicates complete disability [18]. The patient's initial score was 72 (complete disability), and her final score of 6 measured at session 6 indicates no disability as measured and categorized by the HDI tool. The patient also demonstrated a significant decrease of 14 points or 63.6% in self-perceived disability from the initial evaluation to the discharge date as measured by the NDI as the minimum detectable change for this tool is 5 points or 10%.19 Figure 2 demonstrates the patient's decrease in perceived disability secondary to neck pain. When comparing the VAS for this patient from initial evaluation score and discharge score, there appears a clinically significant difference with a decrease of 2.5 points overall with a VAS MDIC of 1.37 [23].

The subject demonstrated improvement in balance in 3 of the 6 NeuroCom testing stages as well as in the SOT composite measure from initial evaluation measurement to her discharge date. Stage

1 of the NeuroCom testing showed a decrease of 2.6% in balance ability while stage 2 showed no change from initial evaluation to discharge though her highest average score during this stage was 94 during session 3. The patient also demonstrated a decrease in overall score for stage 5 of 6.7% with the highest average for this stage being achieved on session 3 at 73 as shown in Table 1. The patient made significant improvements in stages 4 and 6 with an increase in balance performance of 28.3% (20.5 points) and 19.9% (13.5 points), respectively (Figures 2 & 3).

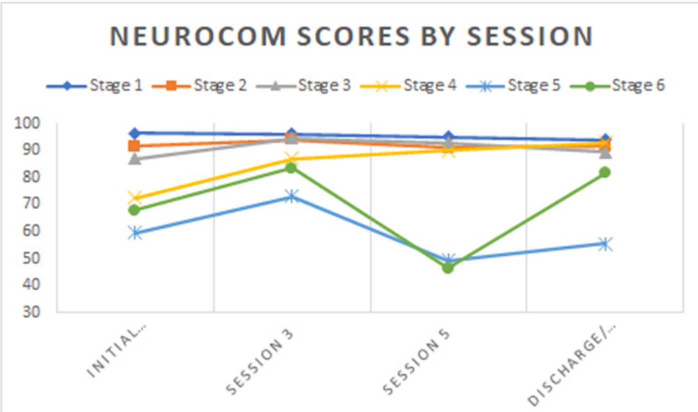

Figure 2: NeuroCom averages by session

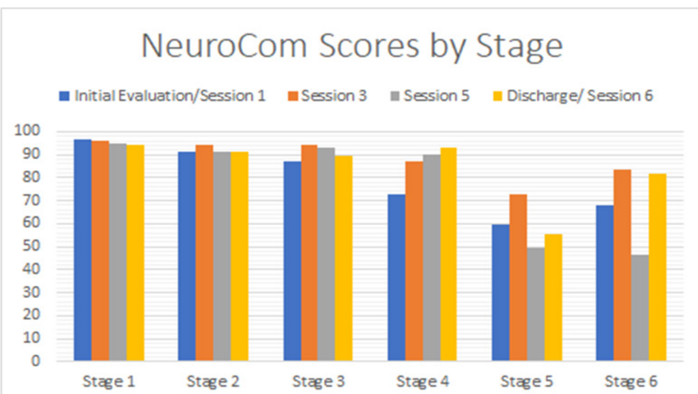

Figure 3: NeuroCom Averages by Stage

Discussion

The purpose of this case study was to identify if balance training in addition to standard physical therapy had an impact on the balance, and overall quality of life in a patient with CEH. The subject in this case report improved in the FRT indicating improved mobility of the atlantoaxial joint. Upper cervical range of motion has been shown to play a role in altered afferent cervical input, which can affect proprioception and balance in an individual, and thus this could have had an impact on her performance on the NeuroCom [8, 13]. As identified in (Table 1), the subject made gains in cervical range of motion in all directions which seems to indicate that her manual therapy interventions were beneficial. The gains in range of motion correlated with a steady decrease in scores on the NDI, HDI, and VAS. All subjective outcome measures met the minimal criteria for a significant minimal clinical important difference. Meeting the MCID indicates a drastic decrease in symptomology experienced by the subject, which was restricting her participation in daily activities. The subject's NFMET showed minimal clinical improvement across the 6-week treatment period with a gain of 7 seconds to produce a total endurance time of 15 seconds overall. The normative value for women for the NFMET is 29.4 seconds, indicating that the patient continues to have decreased endurance of the deep neck flexors [25].

Stage 5 of the NeuroCom SOT appeared the most challenging for the patient as evidenced by the lowest scores gained overall between all stages and sessions. This stage of the NeuroCom testing included disruption of visual input by closing the eyes and simultaneous disruption of the NeuroCom baseboard. The subject also made no improvement in the second stage, which also eliminates visual input, which may indicate that she relies overall heavily on vision to maintain balance. This lack of improvement might indicate that she has learned to compensate for poor proprioceptive feedback from the upper cervical spine with visual control for a prolonged period of time and her 6 weeks training program has not been enough to change this. Additionally, this lack of improvement on stage 5 testing could also be because her home exercise program did not include balance training without visual control. Future studies should explore if balance training without visual control improves balance control in subjects with CEH.

Stage 3 on the NeuroCom challenges the patient through movement of the cage itself and this possibly over stimulated her visual system, which may have contributed to the minimal improvement in balance over time during this stage (Figure 1 and 2). The patient's most significant improvements were seen in stages 4 and 6, where her visual input was not being challenged by closing her eyes or the cage moving. The patient scored a composite score less than 38 only once during stage 6 of the NeuroCom testing as seen in table 1. This may indicate that the more her balance is challenged, particularly when her visual system is eliminated or over stimulated, the more at risk she is for falls.

Over the 6 weeks the patient participated in physical therapy she made substantial gains. Overall, the data received from the NeuroCom testing reveals an increase in balance capabilities shown by the SOT score listed in Table 1. The SOT score is a composite equilibrium score, which is a weighted average of the scores achieved on the 6 conditions of the test [35]. The change in score from initial evaluation to the discharge date for this patient shows an overall 7.9% balance improvement on average for all 6 balance conditions presented during testing. A study by Trueblood et al, was conducted to determine normative values of the SOT by age group. For the 50-59 year old age group, in which this case patient falls, the average scores for each stage and the composite score were as follows: stage 1- 92.97, stage 2- 90.50, stage 3- 89.03, stage 4- 68.77, stage 5- 63.93, stage 6- 61.59, and SOT composite 73.85 [35]. As demonstrated in Table 1, this patient performed above these normative values at the final session for the composite SOT score and all conditions except stage 5 where she performed 8.43 points less than the average reported by the study. However, the patient failed to meet the 63.93 normative value for stage 5 at each visit other than during session 3 where she scored a 73. Future studies should explore if there is a cause-and-effect relationship between the SOT score, upper cervical joint mobility and headache complaints in subjects with CEH.

Conclusion

The subject in this case report reported a significant change in headache symptomology, range of motion, and neck flexor endurance. Additionally, she demonstrated a significant improvement in her balance as measured by the NeuroCom SOT. This subject underwent a specific balance program. Although cause and effect can be determined it appears that this program, resulted in significant gains in balance shown by the NeuroCom SOT scores. This improved balance control suggest that balance training should be a consideration when determining appropriate intervention strategies for patients with CEH. Further studies are needed to further explore the relationship between balance training and cervicogenic headaches.

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