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Case Report

Examination and Treatment of Patients With Unilateral Vestibular Damage, With Focus on the Musculoskeletal System: A Case Series

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Background and Purpose. Persistent dizziness and balance problems have been reported in some patients with unilateral vestibular pathology. The purpose of this case series was to address the examination and treatment of musculoskeletal dysfunction in patients with unilateral vestibular hypofunction.

Case Description. The musculoskeletal system was evaluated with the Global Physiotherapy Examination, dynamic balance was measured during walking with triaxial accelerometers positioned on the lower and upper trunk, and symptoms and functional limitations were assessed with standardized self-report measures. The 4 included patients had symptoms of severe dizziness that had lasted more than 1 year after the onset of vestibular dysfunction and a moderate level of perceived disability. Musculoskeletal abnormalities typically included postural misalignment, restricted abdominal respiration, restricted trunk movements, and tense muscles of the upper trunk and neck. The patients attended a modified vestibular rehabilitation program consisting of body awareness exercises addressing posture, movements, and respiration.

Outcomes. After the intervention, self-reported symptoms and perceived disability improved. Improvements in mobility and positive physical changes were found in the upper trunk and respiratory movements. The attenuation of mediolateral accelerations (ie, body oscillations) in the upper trunk changed; a relatively more stable upper trunk and a concomitantly more flexible lower trunk were identified during walking in 3 patients.

Discussion. The recovery process may be influenced by self-inflicted rigid body movements and behavior strategies that prevent compensation. Addressing physical dysfunction and enhancing body awareness directly and dizziness indirectly may help patients with unilateral vestibular hypofunction break a self-sustaining cycle of dizziness and musculoskeletal problems. Considering the body as a functional unit and including both musculoskeletal and vestibular systems in examination and treatment may be important.

In most patients experiencing acute unilateral vestibular pathology, symptoms of vertigo resolve spontaneously within weeks.[1] However, about 30% of patients may have persistent dizziness,[2,3] imbalance and poor trunk control,[4] and reduced trunk motion and excessive head movements during ambulation.[5] The identification of factors that cause some patients to have chronic dizziness may aid in the design and implementation of appropriate and effective treatment programs.

In a mixed group of patients with a primary complaint of dizziness at the initial consultation, musculoskeletal complaints were the most commonly reported new disorder 12 months later.[6] Whether such complaints are secondary to dizziness is a matter of debate.[6–8] Restricted movements, muscle tension, fatigue, and pain, particularly in the cervicothoracic region, have been described in people with a primary complaint of dizziness.[7,8] Other investigators have reported pulling sensations in the cervical and upper trapezius muscles[9] as well as pain and stiffness in the upper trunk and leg muscles,[10] which can be present chronically, during attacks of dizziness, or both. In a study of 503 patients with dizziness,[11] the percentage of patients reporting neck pain increased from 27% at the initial visit to 59% 5 years later. In a subset of these patients who demonstrated unilateral vestibular hypofunction (UVH) (n=89),[11] neck pain was reported by 21% initially and by 51% over 5 years. The presence of neck pain was a strong predictor of persistent dizziness (odds ratio=2.83).[11]

Examination of patients with UVH is typically directed toward vestibular function and balance and may include a cursory musculoskeletal screen. The focus of traditional vestibular rehabilitation[12,13] is the reduction of symptoms of dizziness, improvement in static and dynamic balance, improvement in gaze stability, and an increase in function. Vestibular rehabilitation may consist of exercises to decrease motion sensitivity (on the basis of principles of habituation), head movements to improve gaze stability (on the basis of principles of adaptation and substitution), and balance exercises[12] and is the treatment of choice for patients with stable UVH.[12] Recovery is thought to be due to changes in the central nervous system and the development of new sensory and behavioral strategies.[14,15] However, vestibular rehabilitation is not beneficial for all patients with UVH.[16]

Although current clinical practice may include examination and treatment of musculoskeletal dysfunction, addressing musculoskeletal dysfunction is seldom reflected in studies on the effectiveness of vestibular rehabilitation. Problems in the musculoskeletal system may be related to persistent symptoms of dizziness. The purpose of this case series was to demonstrate how systematic examination and treatment of musculoskeletal problems may have beneficial effects on the outcome of a vestibular rehabilitation program.[7,8]

Patient History and Review of Systems

The 4 included patients were participants in a longitudinal study[17] approved by the Regional Committee for Medical Research Ethics in Western Norway (written informed consent was obtained). Patients A, B, and C underwent medical evaluation (by an otolaryngologist) in a balance clinic for acute attacks of vertigo (sensation of movement-related dizziness). The initial evaluation occurred at 3, 5, and 13 months after the onset of symptoms in patients A, B, and C, respectively. Patient D was admitted to a hospital with similar symptoms and was seen in the balance clinic on several occasions during the acute and subacute phases. Testing in the balance clinic included an electronystagmography test battery with bithermal caloric testing, Dix-Hallpike positioning tests, computerized balance testing in a standing position (Balance Platform, Cosmogamma, Bologna, Italy),[18] an audiometry examination, and magnetic resonance imaging. Patients A, B, C, and D were seen in the balance clinic again at 7, 24, 1, and 9 months after the initial contact, respectively, and were then referred to a physical therapist because of persistent dizziness or balance problems.

Clinical Impression

On the basis of the medical history and test results, the patients' symptoms could be consistent with UVH (Tab. 1). In all 4 patients, caloric testing revealed canal paresis. Posturography testing revealed sway paths outside norms in 3 patients.[18] Results from magnetic resonance imaging and neurological testing were negative. There was no evidence of other active peripheral nervous disorders, central nervous disorders, or migraine.

The 4 patients had stable vestibular function, but their dizziness and balance problems remained. The persistent problems long after the onset of the vestibular lesion suggested that other factors, such as musculoskeletal dysfunction, could be contributing to their continued symptoms. We considered the patients to be good candidates for demonstrating how examination and treatment of physical dysfunction can contribute to recovery. Examination by the physical therapist was undertaken 1 to 2 weeks before the intervention, a modified vestibular rehabilitation (MVR) program consisting of body awareness exercises addressing posture, movements, and respiration. Re-examination was done immedi-

Table 1.
Information From Medical History and Examinations Before Referral to a Physical Therapist

Information From History or Examination	Patient A	Patient B	Patient C	Patient D
Sex/age (y)	Female/56	Male/42	Male/58	Female/73
Canal paresis (% difference)[a]	89	37	27	97
Medication to reduce dizziness at onset	Yes	No	No	Yes
Posturography path length (mm)[b]	1,996	1,369	831	1,247
Audiometry	Not examined	Negative	Reduced hearing	Extensive loss of hearing in left ear
Other reported complaints		Tension headache, tiredness, problems with concentration, neck and back pain	Short attacks of dizziness associated with double vision and headaches	Pain in left ear, headaches
Medical or other therapies since onset of dizziness		Neck pain treated by physical therapist	Medication for migraine	
Duration of complaint since onset (mo)	10	29	14	9
Medical diagnosis at referral	Vestibular neuritis	Sequel vestibular neuritis	Mixed peripheral/central vestibular disorder?	Vestibular neuritis
Sick leave as percentage of full-time position	50	100	100	

[a] Canal paresis was determined by caloric testing; according to norms, abnormal canal paresis was a left-right asymmetry of greater than 25%.
[b] The posturography path length was determined by static stabilometry, registering of the center of pressure, in millimeters, while the patient stood for 1 minute with eyes closed. The mean path length for people who are healthy is 860 (SD=323) mm.[18] For patient D, posturography was undertaken at her second visit after discharge from the hospital.

ately after completion of the intervention. Patient background information was obtained prior to the physical therapist examination (Tab. 2).

Examination

Examination of the Musculoskeletal System

The musculoskeletal system was examined with the Global Physiotherapy Examination (GPE-52), which allows systematic observation and scoring of body functions and structures for the upper and lower extremities, trunk, and head.[19,20] The GPE-52, developed within the Norwegian psychomotor physiotherapy tradition,[21] includes assessments in 5 main domains (posture, respiration, movement, muscle, and skin); the domains are further divided into 13 subdomains, each incorporating scoring on 4 tests, for a total of 52 items. The full examination takes about 35 minutes. For the posture domain, the positions of the head, shoulder, spine, and knee in relation to the body's longitudinal axis are inspected with the patient in standing and supine positions. For the respiration domain, the degrees of abdominal and thoracic respiratory movements during inspiration are observed and scored with the patient in standing and supine positions. For the movement domain, flexibility and the ability to relax are tested by passive movements of the cervical spine, lumbar spine, and extremities with the patient in standing and supine positions. Passive range of motion of the head and extremities is measured with a goniometer or ruler. Active movements are assessed while the patient moves the jaw, trunk, and feet in the supine position. The muscle domain comprises stretch palpation and compression of specific muscles in the neck (sternocleidomastoid and trapezius), trunk (diaphragm/abdominal and erector spinae), and extremities (triceps, rectus femoris, and gastrocnemius); the patient's verbal reaction is noted. The skin domain is examined through compression and stretch palpation in the same areas as for the palpation of muscles, except in the diaphragm/abdominal area.

Each item is scored according to deviation from a predefined standard (0). The scale has 15 possible scores, ranging from -2.3 to $+2.3$. The bidirectional nature of the scale reflects less or more of a quality relative to the predefined standard. Absolute values indicate degree of dysfunction, with higher scores reflecting more aberrations. Individual test results are added to form an overall summary score and domain and subdomain summary scores.

Satisfactory reliability of the GPE-52 has been demonstrated by intraclass correlation coefficients (ICC [2,1]) of .90 for total score, .60 to .89 for domain scores, and .61 to .88 for subdomain scores and low measurement errors.[22] The GPE-52 discriminates between people who are healthy and patients with long-lasting musculoskeletal pain and, to

Table 2.
Self-Report Information Associated With Dizziness and Balance Problems Prior to the Physical Therapist Examination and Completed Modified Vestibular Rehabilitation (MVR) Sessions

Parameter	Patient A	Patient B	Patient C	Patient D
Duration of complaints since onset (mo)	12	30	16	12
Description of dizziness	Rotational	Rocking	Not able to specify	Rotational/rocking
Falls within last month because of dizziness	No	No	No	No
Previous falls or near falls because of dizziness	Yes	Yes	No	Yes
Regular use of medication for dizziness	No	No	No	No
Regular use of other medication	No	No	No	No
Main complaint	Persistent sensations of dizziness and unsteadiness	Attacks of nauseating dizziness provoked in visually stimulating and noisy settings	Persistent sensations of dizziness	Vertiginous/dizzy sensations reinforced by changes in body positions and neck movements
Attendance at MVR program (no. of times attended/9)	7	6	8	8
No. of times logs returned (maximum no. in 9-wk program=8)[a]			8	7

[a] The patients were given written instructions for a home program adapted from that described by Herdman and Whitney.[12] Two eye-head coordination exercises (viewing paradigms 1 and 2: moving head back and forth and nodding) were to be performed twice per day, 7 days per week. Walking inside or outside in diverse environments was suggested. Reactions to the exercises were noted in logs given to the physical therapist the following week. Information for patients A and B was not available.

some degree, between subgroups of patients.[23] In a previous study, sensitivity to change was demonstrated for all domains after 4 weeks of rehabilitation.[20] The movement and respiration domains were shown to be responsive to clinically important change; the odds of not returning to work increased with increasing scores.[20] In this case report, clinically important change is defined as change greater than or equal to the measurement error (Tab. 3).

Testing of Balance

Balance control was explored during walking[24] with 2 triaxial accelerometers (Logger Technology HB, Malmö, Sweden) positioned on the lower trunk and the upper trunk.[25] Gait is associated with body oscillations (ie, accelerations) that can be registered by accelerometers.[24] Linear accelerations (measured as *g*, the unit of gravity) represented by root-mean-square values reflect the mean amplitude of accelerations across the distance traveled.[26]

Accelerometers measure oscillations in the trunk, and the trunk acts as a filter, attenuating the oscillations.[27] In people who are healthy, this attenuation takes place mainly in the lower trunk before oscillations reach the head, thus providing a stable platform for the head's perception of information from the visuovestibular system.[27,28] Balance control is influenced by the capacity to attenuate body oscillations[28–31]; attenuation along the mediolateral axis is particularly important[32] and is compromised in patients with UVH.[25]

Satisfactory reliability for the mediolateral axis has been demonstrated by ICC (1,1) and ICC (3,1) of greater than or equal to .96.[25] The axis is sensitive to change,[33] but minimal important change has not been established. Analyses were undertaken at a reference walking speed of 1.2 m/s, allowing comparison of individual changes before and after the intervention (Tab. 4).

Self-Reported Information

The severity of symptoms was assessed with the Norwegian short version of the Vertigo Symptom Scale (VSS),[34] which consists of 15 items. The points on the VSS range from 0 to 60. Satisfactory reliability of the VSS has been demonstrated by ICC (1,1) and ICC (3,1) of .88.[34] The test metrics of the VSS are as follows: severe dizziness, ≥12 VSS points; clinically important change, ≥3 VSS points.[35] Perceived disability was assessed with the Norwegian version[36] of the Dizziness Handicap Inventory (DHI), which consists of 25 items. The points on the DHI range from 0 to 100. Satisfactory reliability of the DHI has been demonstrated by ICC (1,1) and ICC (3,1) of greater than .90. The test metrics of

Table 3.
Global Physiotherapy Examination (GPE-52) of and Self-Report Measures for 4 Patients With Persistent Dizziness Before and After the Intervention[a]

Type of Score	Score for:								Measurement Error	$\bar{X}$ (SD) Score for People Who Are Healthy
	Patient A		Patient B		Patient C		Patient D			
	Pre	Post	Pre	Post	Pre	Post	Pre	Post		
GPE-52[b]										
Total summary score	52.3	48.3	34.5	28.5	45.2	36.0	53.8	48.5	3.1	34 (6.4)
1.0 Posture (8 tests)	8.9	7.2	4.2	5.0	6.6	6.3	7.3	7.3	1.1	4.4 (1.5)
1.1 Posture in standing position	5.3	4.6	3.0	2.9	3.0	3.3	4.6	4.3	0.6	2.5 (1.1)
1.2 Posture in supine position	3.6	2.6	1.2	2.1	3.6	3.0	2.7	3.0	0.8	1.9 (1.0)
2.0 Respiration (8 tests)	6.4	6.5	7.7	6.3	4.7	3.3	8.8	4.2	1.1	6.1 (1.3)
2.1 Standing position	4.7	4.4	4.7	4.0	3.0	2.0	4.9	3.0	0.7	3.7 (0.8)
2.2 Supine position	1.7	2.1	3.0	2.3	1.7	1.3	3.9	1.2	0.6	2.4 (0.7)
3.0 Movement (16 tests)	13.4	14.2	8.2	5.2	17.1	12.2	19.6	17.5	1.6	8.5 (3.4)
3.1 Flexibility	5.1	4.6	4.0	0.6	5.9	3.6	5.9	5.9	0.6	3.0 (1.2)
3.2 Passive range of motion	1.6	2.3	1.6	2.3	4.9	3.6	4.3	3.3	0.7	2.1 (1.5)
3.3 Passive movements	2.7	3.3	1.6	1.3	5.3	4.0	6.0	5.7	0.5	1.8 (1.2)
3.4 Active movements	4.0	4.0	1.0	1.0	1.0	1.0	3.4	2.6	0.7	1.6 (0.9)
4.0 Muscle (12 tests)	14.2	11.6	9.8	9.0	10.9	9.8	12.8	13.1	1.4	10.0 (2.3)
4.1 Stretch palpation of muscle	4.7	4.9	3.4	3.6	4.4	3.4	4.7	4.7	0.5	3.9 (1.1)
4.2 Reaction to stretch of muscle	4.6	3.4	3.0	3.1	3.8	3.4	4.0	3.0	0.9	3.0 (1.3)
4.3 Pressure palpation of muscle	4.9	3.3	3.4	2.3	2.7	3.0	4.1	5.4	0.6	3.2 (0.7)
5.0 Skin (8 tests)	9.4	8.8	4.6	3.0	5.9	4.4	5.3	6.4	1.1	5.0 (1.5)
5.1 Pressure palpation of skin	5.0	5.1	2.6	1.0	3.1	2.4	3.0	3.4	0.5	2.9 (0.9)
5.2 Stretch palpation of skin	4.4	3.7	2.0	2.0	2.8	2.0	2.3	3.0	0.8	2.1 (0.9)
Self-reported symptom and disability scores[c]										
Dizziness severity (VSS)	13	1	14	10	25	14	15	16	3	
Perceived disability (DHI)	36	16	44	34	42	28	40	34	11	

[a] For comparison, measurement errors and scores for people who are healthy are shown.[24] Clinically important change (from before the intervention [Pre] to after the intervention [Post]) was defined as change greater than or equal to the measurement error (ie, improvement).
[b] The GPE-52 has 5 domains and 13 subdomains; each subdomain contains 4 tests.
[c] Self-reported symptoms and disability were determined with the Vertigo Symptom Scale (VSS) (range=0–60 points; clinically important change, ≥3 VSS points) and the Dizziness Handicap Inventory (DHI) (range=0–100 points; minimal important change, 11 DHI points).

the DHI are as follows: cutoff for disability, 29 DHI points; minimal important change, 11 DHI points (Tab. 3).[36]

Clinical Impression

All patients reported severe dizziness and moderate disability (Tab. 3). The presence of musculoskeletal aberrations was confirmed (Tab. 3). Typical findings were protracted head and shoulders (postural misalignment), reduced trunk flexibility and ability to relax, tense muscles of the upper trunk and legs, and restricted abdominal breathing. In patient A, physical dysfunctions (according to the GPE-52) were found in the posture, movement, muscle, and skin domains and in a subdomain of respiration. Patient B had physical dysfunctions in respiration only, and patient C had physical dysfunctions in posture and movement. In patient D, physical dysfunctions were found in the posture, respiration, movement, and muscle domains. In patients C and D, dysfunctions in the movement domain were the primary findings.

With respect to balance during gait, accelerations were larger in the lower trunk than in the upper trunk in all 4 patients. Larger upward attenuation was seen in patients A, B, and C (27%–35%) than in patient D (3%) (Tab. 4).

Table 4.
Trunk Acceleration Along the Mediolateral Axis in the Lower and Upper Trunk During Walking[a]

Acceleration	Patient A		Patient B		Patient C		Patient D	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
RMS *g* value for lower trunk	0.181	0.153	0.124	0.156	0.172	0.190	0.115	0.147
RMS *g* value for upper trunk	0.119	0.106	0.080	0.091	0.125	0.127	0.112	0.122
Attenuation of trunk acceleration from lower to upper trunk (%)	34	31	35	42	27	33	3	17
Change in attenuation from before intervention to after intervention (%)		−3		7		6		14

[a] Pre=before the intervention, Post=after the intervention, RMS=root-mean-square, *g*=unit of gravity (m/s^2). Calibration of the accelerometers against gravity was carried out on a horizontal surface before each test session. Patients walked at 3 self-administered speeds (slow, preferred, and fast) across an 8.5-m marked path. Time was registered during steady-state walking (middle 4.3 m) by photoelectric cells connected to a computerized stopwatch. A velocity of 1.2 m/s (the mean preferred walking speed) was used to explore RMS *g* values at the lower and upper trunk and upward attenuation along the mediolateral axis.[25,26]

The findings emphasized the need to address musculoskeletal dysfunctions in treatment. We considered these cases appropriate for our MVR program.

Intervention

The MVR program[17] (Tab. 5) comprises a combination of elements from traditional vestibular rehabilitation[12] and body awareness exercises from the Norwegian psychomotor physical therapy tradition, which typically is directed toward musculoskeletal problems.[21] This tradition assumes that patients with long-

Table 5.
Examples of Physical Exercises in the Modified Vestibular Rehabilitation (MVR) Program[a]

Category	Exercise	Comments and Suggestions for Progression
Body awareness training	Postural alignment in standing position	Making a conscious effort to register own position in relation to gravitational line and distribution of body weight in relation to ground
	Postural alignment during walking	Enhancing awareness of body during walking through reflective instructions[b]; gradually increasing tempo
Habituation exercises	Circular head movements	Progression: from sitting to standing; standing on foam with eyes open and with eyes closed
	Making circles holding a ball in both hands; visual fixation on the ball during movement	Increasing tempo
Adaptation exercises	Eye-head exercises: fixation of eyes on a defined target; moving the head from side to side and up and down	Progression: from sitting to standing; from standing on even surface to standing on foam; fixation of eyes during combined movement of head and movement of target
Balance and functional exercises	Standing with feet together; sitting on a therapeutic ball	Standing on 1 leg; standing on foam; standing on balance boards
	Walking with abrupt change in direction on commands without bumping into other people or objects	Progression: increasing tempo; varying floor surface by introducing mats on floor
	Walking with head movements from side to side	Progression: varying floor surface by introducing mats on floor
	Picking up things from the floor	Progression: from large to smaller balls
	Throwing and catching a ball	
Relaxation	Various methods for promoting relaxation	Sitting and lying positions; massage techniques
Home exercise program	Specific eye-head exercises; balance exercises; general progressive walking programs	Progressively making aforementioned exercises more difficult; incorporating arenas with maximal stimuli, eg, a supermarket on a Saturday

[a] Adapted with permission from Kvåle et al[17] and publisher John Wiley & Sons Ltd.
[b] Examples of reflective questions or instructions from the physical therapist to the patient during walking: Is your walking relaxed? How is your foot-floor encounter? How is your breathing while walking? How is your head positioned? Are your arms moving in a relaxed manner during walking?

lasting physical problems, psychological problems, or both react with general body aberrations (eg, posture, respiration, movements, the ability to relax, and muscle tension) that can be addressed by body awareness exercises. Our MVR differs from traditional vestibular rehabilitation by having a less direct focus on dizziness. Attention is directed toward establishing contact between the feet and the ground; this process is reinforced by conscious reflections on what happens in the body through reflective questions and instructions, thereby enhancing proprioceptive stimulation. Dizziness, when provoked, is managed by encouraging the patient to accept the dizzy sensations and to focus on being grounded, stable, and relaxed. Treatment also includes relaxation exercises with an indirect focus on respiration. Progress is regulated individually under the guidance of the physical therapist and includes variations in speed, range of motion, starting positions, and environmental conditions. This process-oriented, sensorimotor training facilitates changes in affected body functions[37] and is useful in patients with long-lasting musculoskeletal pain.[38–40]

The MVR was given as a group treatment (5–8 patients) once per week for 9 weeks, with 90 minutes per session (60 minutes of exercises and 30 minutes of reflection and discussion). A home program was included.

Outcome

Self-reported dizziness improved in patients A, B, and C, the improvements ranging from 4 to 12 VSS points (VSS minimal important change: ≥3 points). In patient D, symptoms remained unchanged. No disability was perceived by patients A and C, who had improvements of 20 and 14 DHI points, respectively (DHI minimal important change: 11 points). A moderate level of disability remained in patients B and D, although reductions of 10 and 6 points, respectively, were seen (Tab. 3).

Overall scores in the GPE-52 improved in all patients (Tab. 3). The main improvements in patient A were identified in the posture (change score=1.7) and muscle (change score=2.6) domains. In patients B, C, and D, improvements were identified in the respiration (change scores=1.4–4.6) and movement (change scores=2.1–4.9) domains. These changes were above the measurement error, here defined as clinically important change (Tab. 3). In patients B, C, and D, some changes were also identified in different muscle subdomains.

After the intervention, accelerations measured in the lower trunk and upper trunk during gait decreased in patient A but increased in patients B, C, and D (Tab. 4). In the latter 3, accelerations increased more in the lower trunk (10%–28%) than in the upper trunk (2%–14%). Relative to attenuation before the intervention, attenuation after the intervention decreased in patient A but increased in the other 3 patients (Tab. 4).

Discussion

At 12 to 30 months after the onset of vestibular pathology, all 4 patients reported severe dizziness and a moderate level of disability. Before the intervention, they had measurable musculoskeletal abnormalities in posture (protraction of head and shoulders) and respiration (restricted), in the trunk (reduced flexibility and ability to relax), and in muscles (increased tension in muscles in the upper trunk and legs). After the MVR program, improvements were seen in all patients. Improvements were identified in respiration and in the trunk (flexibility). Less tense muscles were registered in the upper trunk region and, to some extent, in the legs. Postural improvement was identified in 1 patient. Three of 4 patients showed improvements in balance control. Improvements in dizziness and level of disability were seen in 3 patients.

Preintervention Findings

The degree of musculoskeletal aberrations detected before intervention in patients A, C, and D corresponded to that in patients with long-lasting musculoskeletal pain (Tab. 3).[23] The overall summary score in patient B was similar to that in people who are healthy[23]; his trunk flexibility, however, was hampered. The postural misalignments (protracted head and shoulder positions) identified in patients A, C, and D have been reported in patients with UVH[9,41] but are not common in people who are otherwise asymptomatic.[41,42] In patients A and C, the misalignment was probably influenced by the duration of the condition[41]; in patient D, older age could also have been a factor.[41,42] Postural misalignment represents a problem because it can hamper vestibular compensation.[41] Even subtle anterior weight shifts, such as that caused by protracted head and shoulders, can increase the tension in antigravity muscles to counteract biomechanical disadvantages. Such a scenario may explain the increased muscle tension registered in the upper trunk and legs in patients A and D. Hyperactivity of muscles in the upper trunk has been described in patients with acute vestibular lesions[43] and could have a negative influence on the ability to relax.

Reduced trunk flexibility was identified in patients A, C, and D and has been reported by other authors.[4,5,9] A rigid trunk may influence balance, which is dependent on a versatile body.[21]

Restricted respiration was seen in patients A, B, and D. Increased muscle tension (like that seen in patients A and D, in particular) and reduced trunk flexibility may influence free respiratory movements.[44] Another element that may hamper free respiratory movements is fear[21]; patients may fear that movement will provoke dizziness.

Postintervention Outcome

All patients completed the MVR program, although none attended the maximum number of treatment sessions (Tab. 2). There is no consensus on the optimal length of treatment.[45] Dizziness improved in patients A, B, and C, but there was no change in patient D's reports. Changes of various degrees and in different domains were seen for the musculoskeletal system.

Minimal detectable change is usually calculated as measurement error $\times$ $(1.96 \times \sqrt{2})$.[46] This large, statistically significant change was seen in patient B (flexibility), patient C (total score and movement domain, particularly flexibility), and patient D (respiration domain, particularly in the supine position) (Tab. 3). The use of statistical change only may result in overlooking changes that are clinically relevant.[47] Clinically important change can be defined within a specific context,[47] and the measurement error can be used to reveal change that may have an impact on everyday life. In this case report, change greater than or equal to the measurement error was used for the interpretation of meaningful change.

The normal trunk-head stabilization process during gait is influenced by the capacity to attenuate trunk accelerations.[27,28,30] This process seems to be disturbed in people with vestibulopathy,[4,5,48,49] resulting in balance control problems. All 4 patients displayed cranially directed attenuation similar to that in people who are healthy.[28,31] Calculations based on the results of studies of people who are healthy[50,51] revealed attenuation values between 27% and 42% and between 9% and 19% in young people (23–29 years) and elderly people (74–75 years), respectively. The data could indicate that attenuation was sufficient before the intervention in patients A, B, and C but reduced in patient D (Tab. 4). However, improved attenuation after the intervention implied that attenuation before the intervention was suboptimal. The observed changes could be interpreted as some improvement in patients B and C and a large improvement in patient D. In patient A, a small, negative change most likely did not alter balance control.

Body Strategies After Intervention

Two patterns emerged after intervention—that of patient A and that of patients B, C, and D. In patient A, a restriction of accelerations in the upper trunk (Tab. 4) may have reflected improved head control.[27] However, combined with the concomitant larger restriction of accelerations in the lower trunk, a dysfunctional strategy of limited trunk flexibility could have compromised effective head control. The results were consistent with the musculoskeletal findings: improvement only in the posture and muscle domains and not in the movement domain. This strategy may be useful in the short term; the patient reported no problems related to dizziness or disability (Tab. 3). Over time, such a strategy may result in dysfunctional balance control.

In patients B, C, and D, increased accelerations were seen in the lower and upper trunk (Tab. 4). Accelerations increased more in the lower trunk; thus, the relative restrictions in the upper trunk could be interpreted as improved head control.[27] In combination with concomitant increased flexibility in the lower trunk, those findings are consistent with our findings for the musculoskeletal system. The changes most likely resulted in a more stable platform from which vestibular and visual information could be processed.[30] This strategy may be more useful with respect to balance control in the long term. Dizziness and perceived disability improved for patients B and C but not for patient D (Tab. 3).

Theoretical Justification

Assessment and treatment based on the Norwegian psychomotor physiotherapy tradition[21] are focused on the musculoskeletal system. In this approach, a local impairment such as UVH has a global impact, resulting in dysfunctional body strategies. Head-trunk locking is an example of a dysfunctional strategy for avoiding dizziness, as the strategy may also result in muscle tension and pain.[21] Another strategy is the minimization of trunk movements during walking, as also described by others.[5,7–9] A rigid trunk can be described as having reduced degrees of freedom and thereby limiting the body's capability to meet demands from the task and environment. Capability can be even further limited if or when both strategies are combined. The strategies, which are conscious at first, become automatic over time.[52] The strategies are counterproductive because symptom-provoking movements are central for recovery from UVH[53] and a flexible body is necessary for optimal balance.[21] The musculoskeletal system may become a predisposing factor; restricted movement can perpetuate dizziness, and anxiety and fear can further reinforce problems—including those with respiration, which is closely associated with fear and emotions.[21,44]

A versatile body can change,[21] and direct learning experiences are powerful mechanisms for inducing change.[52] The focus of the MVR program is body awareness rather than dizziness. Redirecting focus is a well-known element in learning new behavior and stress reduction strategies.[52] Increased reliance on proprioception for postural control is seen even in people with UVH and good compensation.[54] Interventions that stress body awareness, as also suggested by others,[41,45] enhance proprioception. Further reinforcement can be provided through reflection on one's own performance, with support from verbal explanation and guidance provided by a physical therapist.[52] In our MVR program, patients learn through direct experience that it is safe to move; thus, the program helps patients overcome fear and thereby reduces the self-sustaining mechanisms hampering improvement. The program is provided in a group format,[17] which takes advantage of the possibility for indirect learning through observation of and discussion with fellow patients,[52] as originally described by Cooksey.[13]

Clinical Implications

Traditional examination of patients with a vestibular disorder is probably too fragmented to capture the consequences of secondary musculoskeletal problems.[7,8] A more global examination that addresses where and to what extent patients have physical aberrations is needed.

Treatment should then be focused on the identified musculoskeletal problems, in particular, respiration, flexibility, and muscle tension. A body awareness approach with an indirect focus on dizziness has the potential to reduce symptoms and disability and break the self-sustaining dizziness-musculoskeletal impairment cycle. We argue that a group setting is valuable because patients face the same challenges and can learn from each other. Although individualized treatment is considered the gold standard, specific individual needs can be met by the physical therapist as long as the group size is reasonable.

Future Research

The GPE-52 may be too time-consuming in busy clinical settings. It is important to ensure that musculoskeletal examination is undertaken, and we are currently exploring the use of fewer tests for the examination of patients. The domains of the GPE-52 are reciprocally dependent and interactive.[20] Associations among changes in posture, movement, muscles, and respiration seem to be clinically sensible, but the relationships between changes in dizziness and changes in musculoskeletal function need to be explored. In this case report, postural misalignments were registered, and changes could be observed clinically but not well measured. A more sensitive subscale for measuring posture has been developed,[55] but further testing and refinement are needed.

Trunk accelerations and attenuation during gait reflect underlying control strategies.[33] Most likely, individual differences need to be explored. Clinically important change values should be determined.

In the GPE-52, patients are examined in standing and supine positions, which require control strategies different from those required for walking. An association (r=.63, P<.01) between changes in posture scores and changes in attenuation along the mediolateral axis was previously reported[56] and needs to be explored further.

The impact of musculoskeletal factors on recovery from UVH has not been explored.[57] It may be possible to influence physical function, and studies that focus on the musculoskeletal system in cases of UVH are needed. We plan to pursue such studies.

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