Impaired Standing Balance in Individuals with Cervicogenic Headache and Migraine

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Aims: To determine whether a difference in standing balance exists among individuals with cervicogenic headache, those with migraine, and asymptomatic controls. **Methods:** A total of 24 participants with cervicogenic headache, 24 with migraine, and 24 asymptomatic controls of similar age, gender, and body mass index were included. Standing balance was assessed with a swaymeter under the conditions of eyes open and closed; on firm and soft surfaces; and in comfortable and narrow stances (for a total of eight testing conditions). Each condition was tested for 30 seconds. The outcome measures were sway area and displacement. Multivariate analysis of variance with Bonferroni post hoc test were used to analyze between-group differences in the postural sway variables. **Results:** Both headache groups had significantly larger sway areas than the control group during comfortable stance with eyes open and with eyes closed on a soft surface ($P < .05$) and during narrow stance with eyes closed on firm and soft surfaces ($P < .05$). The overall results demonstrated significantly greater sway in the anterior-posterior direction and less sway in the medial-lateral direction in selected tests in the cervicogenic headache group compared to the migraine group. **Conclusion:** Individuals with cervicogenic headache and those with migraine have impaired balance during standing, but possibly to a different extent and pattern. Assessment of balance in patients with cervicogenic headache and migraine should be considered in clinical practice. *J Oral Facial Pain Headache 2018;32:321–328. doi: 10.11607/ofph.2029*

Keywords: *balance, cervicogenic headache, headache, migraine, sensorimotor dysfunction*

Neck-associated symptoms are characteristics of cervicogenic headache and are also common in migraine.[1–3] Although the pathogenesis of these two headaches is different, the basic mechanisms of spread and referral of pain in both cervicogenic headache and migraine are mediated through a dynamic bidirectional interaction in the trigeminocervical complex.[4,5] However, cervicogenic headache originates in the upper cervical spine, whereas the cause of migraine is suggested to be associated with inflammation of the meninges, changes in blood vessels, or changes in hypothalamic and brainstem neurons.[6,7] A spreading wave of cortical activation/depression is also suggestive of an aura-like phenomenon in migraine.[7] Previous studies have demonstrated that cervical musculoskeletal impairment is a typical feature of cervicogenic headache.[8,9] Additionally, a pattern of cervical musculoskeletal impairment inclusive of upper cervical joint dysfunction combined with restricted cervical motion and impairment in muscle function can distinguish cervicogenic headache from other headache forms, including migraine.[8] These features are clinically informative for diagnosis and also provide directions for specific management.

The upper cervical spine has a greater amount of proprioceptive receptors than the caudal region of the spine.[10–12] Integration of the sensory inputs from visual, vestibular, somatosensory, and cervical receptors is important for maintaining postural stability.[13,14] In patients with neck pain, evidence suggests that altered cervical afferent input due to a changed or disturbed sensitivity of cervical mechanoreceptor and muscle spindle activity can affect postural stability and pose challenges to the postural control system.[15–17] In addition, the balance deficits were found to be greatest in the anterior-posterior direction and were thought to reflect somatosensory impairment.[18,19] Interestingly, a decreased stability during standing has also been shown in patients with migraine.[20–22] The exact mechanism for the balance deficits in migraine is unclear, but it was suggested to be associated with dizziness or subclinical lesions in the vestibular or cerebellar systems.[21]

Balance control is important not only to maintain postural stability, but also to assure safe mobility-related activities.[23,24] Impaired balance is known as one of the main risk factors for falls.[25] As yet, there is no evidence of balance deficits in individuals specifically with cervicogenic headache, but a decline in postural stability similar to that seen in individuals with neck pain would be expected in patients with cervicogenic headache due to altered cervical input from the upper cervical spine.[6,26] Furthermore, due to the differences in the cause of headache types, a difference in the nature of balance deficits between patients with cervicogenic headache and those with migraine might also occur, but this remains unknown. Understanding postural stability in individuals with cervicogenic headache and migraine may improve clinical assessment and optimal strategies for management in these populations. Thus, the aim of this study was to determine whether a difference in standing balance exists between individuals with cervicogenic headache compared to those with migraine and asymptomatic controls. It was hypothesized that *(1)* individuals with cervicogenic headache and those with migraine would have greater postural sway than asymptomatic controls and *(2)* individuals with cervicogenic headache and migraine would have differences in postural sway, with increased sway in the anterior-posterior direction in those with cervicogenic headache due to different mechanisms causing the balance disturbances.

Materials and Methods

Participants

The sample size was calculated based on the following assumptions: a general linear model; medium effect size; a power of 80%; and a significance level of .05. A total sample size of 72 was required for the study; thus, a total of 72 participants (24 with cervicogenic headache, 24 with migraine, and 24 asymptomatic controls) were recruited from local hospitals, clinics, and the community. The participants were matched on age (range: 18 to 59 years), gender, and body mass index (BMI; range: 18 to 25 km/m^2).

Participants with cervicogenic headache or migraine had headache at least once per month for the past year. Headache was diagnosed by a neurologist according to the criteria of the Cervicogenic Headache International Study Group (CHISG)[27] for cervicogenic headache and the International Headache Society[28] (IHS) for migraine. Participants with cervicogenic headache all scored ≥ 10/100 on the Neck Disability Index (NDI)[29] and underwent a physical examination by an experienced physical therapist to confirm a pattern of cervical musculoskeletal impairments for diagnosis of cervicogenic headache. These examinations included restricted range of motion of upper cervical rotation (assessed by use of a cervical range of motion [CROM] device), palpable upper cervical joint dysfunction (pain provoked by manual examination > 2/10 in combination with the physiotherapist's rating of moderately or markedly abnormal tissue compliance), and poor performance on the craniocervical flexion test, which used a pressure biofeedback (≤ 26 mmHg).[8,30] The asymptomatic group had no symptoms of headache, neck pain, or dizziness for at least the past year by subjective examination. Participants were excluded if they had history of mixed or multiple headaches, a previous history of traumatic neck injury/surgery, known or suspected vestibular pathology, neurologic deficits, visual problems, musculoskeletal injuries/disorders that could interfere with balance tests, cognitive impairment, and/or taking more than four medications. Ethical approval was gained from the ethical review committee for research in humans according to the Declaration of Helsinki (AMSEC-57EX-117), and all participants signed a written informed consent before commencement of the study.

Questionnaires

A screening questionnaire was used to evaluate whether participants met the inclusion criteria. A general questionnaire was then administered to collect demographic data. Participants with headache also completed a headache questionnaire developed to include headache characteristics (ie, duration, frequency, intensity on a 0–10 visual analog scale [VAS], location, and associated symptoms), the presence of dizziness (yes/no), and self-reported neck disability (Neck Disability Index [NDI]-Thai version).[29] The NDI-Thai version has shown good reliability and validity.[29]

Postural Sway

A swaymeter was used to measure body displacements in the horizontal plane at waist level during standing.[31] It has been shown to be a simple and reliable tool for assessing postural sway.[32] The swaymeter consisted of a 40-cm-long rod with a vertically mounted pen at its end, which was firmly attached to the participant's waist (Fig 1). The participant's body sway was recorded on millimeter graph paper fixed on an adjustable-height table. The postural sway in the maximum anterior-posterior (AP_{max}) and medial-lateral (ML_{max}) displacements and the total sway area ($AP_{max} \times ML_{max}$) were computed for analysis of each of the test conditions based on the supplier's method (Neuroscience Research) (Fig 2). A pilot study for intrarater (between-day) reliability testing was performed in 10 patients with neck pain (mean ± standard deviation [SD] age = 28.2 ± 6.8). The results showed good to excellent reliability of the swaymeter in patients with neck pain (intraclass correlation coefficient [$ICC_{3,1}$] range: 0.6 to 0.9 [95% confidence interval (CI) 0.1 to 0.99]) for sway area, 0.6 to 0.9 [95% CI 0 to 0.96] for displacement in AP direction, and 0.6 to 0.8 [95% CI 0 to 0.96] for sway displacement in ML direction).

A modified clinical test of sensory interaction on balance (mCTSIB)[33] was used to determine postural sway during standing with comfortable and narrow stance widths. Participants were tested under four conditions for each stance width: *(1)* eyes open on firm surface; *(2)* eyes closed on firm surface; (*3)* eyes open on soft surface (foam block); and *(4)* eyes closed on soft surface (foam block), for a total of eight tests.[34] For the comfortable stance position, participants stood with their feet approximately shoulder width apart, while for the narrow stance position, they stood with their feet together. Participants were tested barefoot and asked to stand still without talking for 30 seconds for each condition. To avoid their learning over trials and to limit fatigue, only one trial per condition for each stance was used. The testing order was random for each participant. Participants were allowed a maximum of two additional attempts if they were unable to maintain the position for 30 seconds. A rest period of 60 seconds was given between each condition. The tests were assessed by an independent assessor who was blinded to the participant's condition.

Statistical Analyses

Kolmogorov-Smirnov test was used to determine whether data were normally distributed. One-way analysis of variance (ANOVA) was used to analyze differences between groups for demographic data

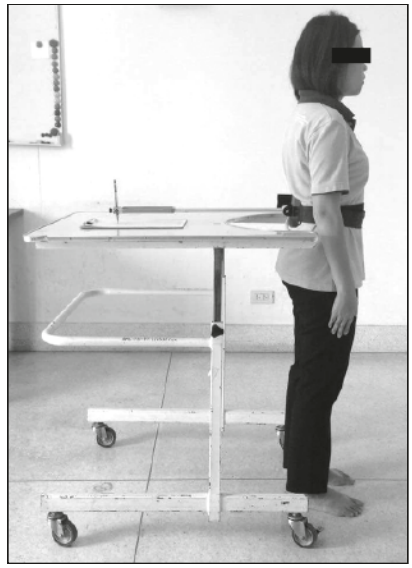

Fig 1 Assessment of postural sway by use of a swaymeter.

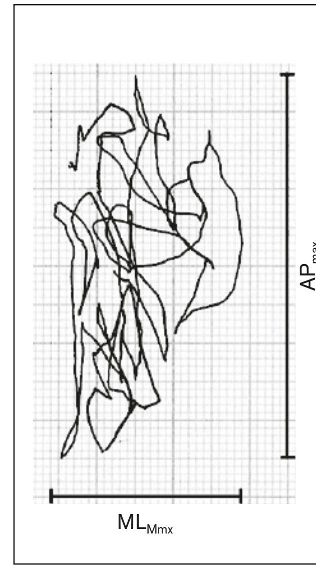

Fig 2 Postural sway in the maximum anterior-posterior (AP_{max}) and medial-lateral (ML_{max}) displacements.

(age, BMI, and NDI score). Independent *t* test was used to analyze differences between the headache groups for headache intensity, Mann-Whitney test for headache duration, and chi-square test for headache frequency and the associated symptoms. Due to non-normally distributed data of the sway area and displacement, logarithmic transformation was applied prior to analysis. Multivariate ANOVA (MANOVA) with Bonferroni post hoc test were used to analyze differences in the postural sway variables between the groups. All statistical analyses were analyzed by SPSS (version 17.0), and significance level was set at .05.

Results

Demographics of Participants

Demographic characteristics for the control and headache participants are presented in Table 1. There were no significant differences between groups for gender, age, or BMI ($P > .05$). In the cervicogenic headache group, 16 participants had unilateral symptomatic joint dysfunction of the upper cervical segments, and all had limited range of upper cervical rotation (mean ± SD = 22.3 ± 5.3 degrees) and poor performance in craniocervical flexion (12 at 22 mmHg, 7 at 24 mmHg, and 5 at 26 mmHg). Intensity and duration of headache were greater in the migraine group, whereas the NDI score was higher in the cervicogenic headache group ($P < .05$). There was no significant difference in headache frequency between the headache groups ($P > .05$). Associated symptoms of aura, nausea, vomiting, and sensitivity to light were greater in the migraine group compared to the cervicogenic headache group ($P < .05$). No significant differences in associated symptoms of dizziness, unsteadiness, sensitivity to

Table 1 Demographic Characteristics of Participants

	Control (n = 24)	Cervicogenic (n = 24)	Migraine (n = 24)
Gender, % female	79.2	79.2	79.2
Age (y), mean (SD)	27.5 (10.6)	27.5 (10.7)	28.8 (8.8)
BMI (kg/m2), mean (SD)	21.4 (2.4)	22.1 (2.6)	22.1 (3.5)
Headache duration (y), mean (SD)	–	2.4 (1.4)	7.1 (5.7)[a]
Headache intensity (VAS, 0–10), mean (SD)	–	5.0 (1.9)	6.0 (1.6)[a]
Headache frequency			
≥ 15 days/month, %	–	20.8	12.5
NDI (0–100), mean (SD)	1.6 (2.7)	23.0 (9.6)[b]	11.6 (6.1)[a,b]
Associated symptoms, n			
Aura	–	0	12[a]
Dizziness	–	13	8
Unsteadiness	–	12	12
Nausea	–	10	18[a]
Vomiting	–	2	10[a]
Sensitive to light	–	13	21[a]
Sensitive to noise	–	6	12
Blurred vision	–	14	17
Dysphagia	–	1	4

[a]*P* < .05 compared between the headache groups. [b]*P* < .001 compared to controls.
SD = standard deviation; VAS = visual analog scale; BMI = body mass index; NDI = Neck Disability Index.

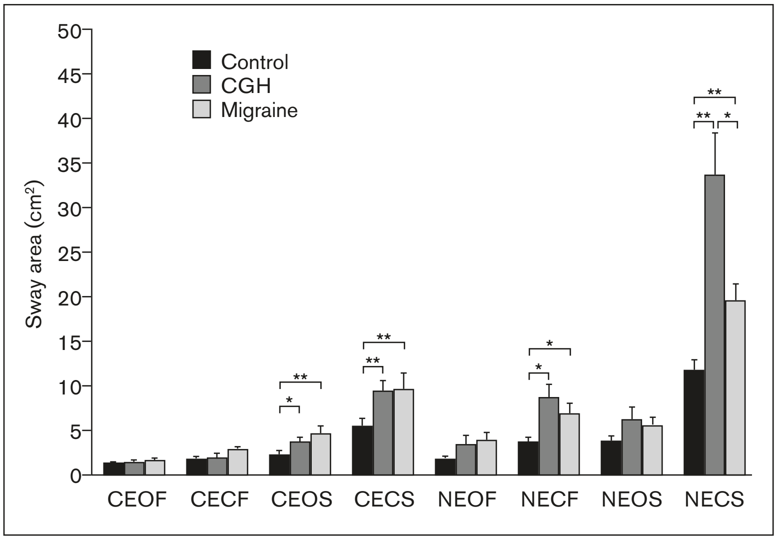

Fig 3 The mean and standard error values for sway areas during the test conditions for the headache and control groups. CEOF = comfortable stance with eyes open on firm surface; CECF = comfortable stance with eyes closed on firm surface; CEOS = comfortable stance with eyes open on soft surface; CECS = comfortable stance with eyes closed on soft surface; NEOF = narrow stance with eyes open on firm surface; NECF = narrow stance with eyes closed on firm surface; NEOS = narrow stance with eyes open on soft surface; NECS = narrow stance with eyes closed on soft surface; CGH = cervicogenic headache. **P* < .05; ***P* < .001; using logarithmic transformation.

noise, blurred vision, or dysphagia were found between the headache groups (*P* > .05). Seven participants in the migraine group and 14 in the cervicogenic headache group had headache on the testing day. In the migraine group, 22 participants took medication (ergotamine 1 mg/caffeine 100 mg or ibuprofen 200 mg) and 2 received nondrug treatment (eg, lifestyle advice, cold pack, exercise, and/or massage) to relieve their headaches. Eleven participants in the cervicogenic headache group took medication (paracetamol 500 mg), and the remainder received conservative treatment (eg, hot/cold pack, balm, and/or massage).

Postural Sway

All participants completed all conditions tested. The mean values for the postural sway areas and the AP_{max} and ML_{max} values during standing with comfortable and narrow stance widths are presented in Figs 3 and 4. Preliminary analyses revealed no differences in postural sway outcomes between headache participants who did and did not have headache on the testing day (*P* > .05) or between the associated symptoms and postural sway (*P* > .05).

Sway Areas

The MANOVA results revealed significant differences among the three groups in sway areas during comfortable stance (Pillai's Trace = 0.3, F [8,134] = 3.1, *P* = .003) and narrow stance (Pillai's Trace = 0.4, F [8,134] = 4.6, *P* < .001). The post hoc results showed that the cervicogenic and migraine groups had significantly larger sway areas than the control group during comfortable stance with eyes open and with eyes closed on a soft surface (all *P* < .05) and during narrow stance with eyes closed on firm and soft surfaces (all $P < .05$). The cervicogenic headache group had greater sway area during narrow stance with eyes closed on a soft surface compared to the migraine group ($P < .05$) (Fig 3).

Sway Displacements

The MANOVA results revealed significant differences among the three groups in sway displacements in the AP_{max} and ML_{max} values during comfortable stance (Pillai's Trace = 0.3, F [8,134] = 2.4, $P < .001$; Pillai's Trace = 0.3, F [8,134] = 2.6, $P < .01$, respectively) and narrow stance (Pillai's Trace = 0.5, F [8,134] = 4.9, $P < .001$; Pillai's Trace = 0.4, F [8,134] = 4.6, $P < .001$, respectively) (Fig 4).

In the AP direction, the cervicogenic headache group had significantly larger sway displacement than the control group during four tests; ie, comfortable stance with eyes open and with eyes closed on a soft surface and narrow stance with eyes closed on firm and soft surfaces (all $P < .05$). The migraine group had significantly greater sway displacement than the control group during four tests; ie, comfortable stance with eyes open on firm and soft surfaces and narrow stance with eyes closed on firm and soft surfaces (all $P < .05$). The cervicogenic group had a greater sway in the AP direction in narrow stance with eyes closed on a soft surface compared to the migraine group ($P < .05$) (Fig 4a).

In the ML direction, the cervicogenic headache group had significantly larger sway displacement than the control group in one test—narrow stance with eyes closed on a soft surface ($P < .001$). The migraine group had significantly larger sway than the control group in three tests: comfortable stance with eyes open and with eyes closed on a soft surface and narrow stance with eyes closed on a soft surface (all $P < .05$). The cervicogenic group had less ML sway in comfortable stance with eyes closed on a firm surface compared to the migraine group ($P < .05$) (Fig 4b).

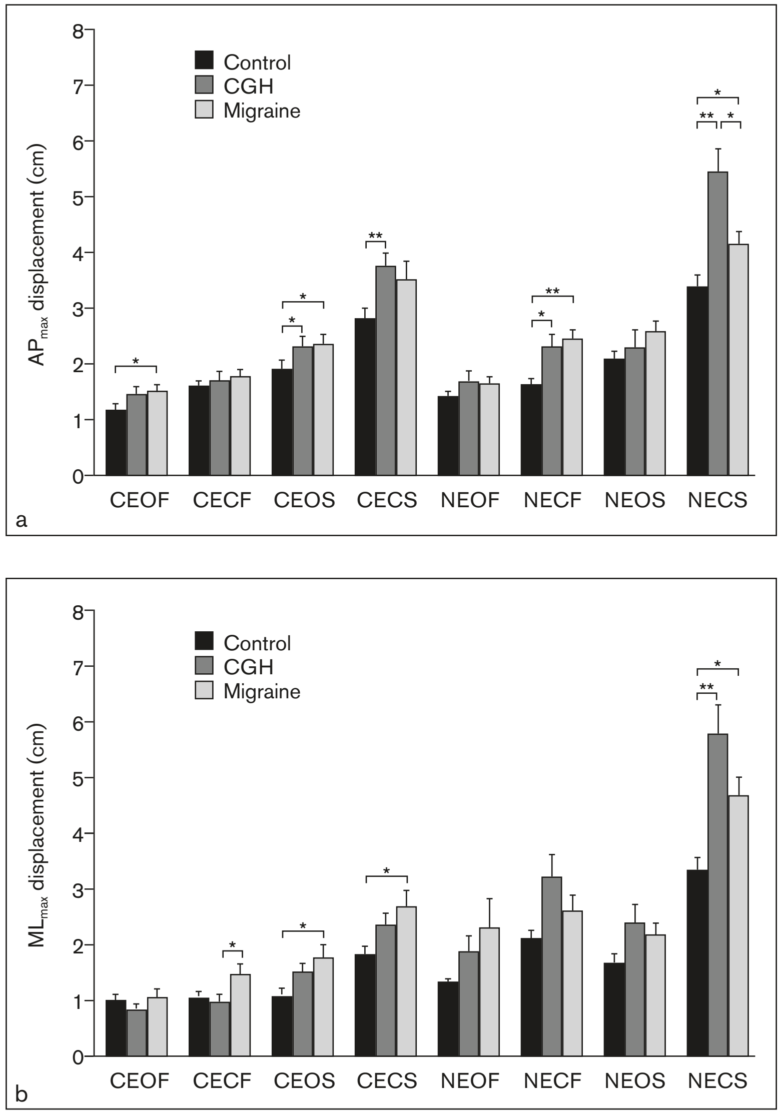

Fig 4 The mean and standard error values for sway displacements for the test conditions in **(a)** the anterior-posterior (AP_{max}) and **(b)** medial-lateral (ML_{max}) directions between the headache and control groups. CEOF = comfortable stance with eyes open on firm surface; CECF = comfortable stance with eyes closed on firm surface; CEOS = comfortable stance with eyes open on soft surface; CECS = comfortable stance with eyes closed on soft surface; NEOF = narrow stance with eyes open on firm surface; NECF = narrow stance with eyes closed on firm surface; NEOS = narrow stance with eyes open on soft surface; NECS = narrow stance with eyes closed on soft surface. *$P < .05$, **$P < .001$; using logarithmic transformation.

Discussion

The present results have demonstrated that subjects with cervicogenic headache and those with migraine had impaired balance during quiet standing compared to asymptomatic control subjects in selected tests. Furthermore, there were some differences between headache groups with respect to different test conditions and the direction of the sway. These findings indicate the occurrence of postural sway alterations in both cervicogenic headache and migraine patients, but perhaps to a different extent and pattern.

Cervicogenic Headache

Consistent with previous studies of neck pain,[35–38] participants with cervicogenic headache had greater postural sway than asymptomatic controls under certain testing conditions. The results suggest that these participants could manage well when standing with a comfortable stance on a firm surface, but had difficulty when standing in more challenging conditions (ie, soft surface for comfortable stance and eyes closed in narrow stance) compared to asymptomatic controls. Additionally, greater postural sways were primarily seen in the AP direction, which is consistent with patterns observed in those with chronic neck pain and back pain[36,37,39] and likely reflects somatosensory impairment as the cause of the postural instability in this group.[18,19] Conversely, postural instability in the ML direction would be expected for vestibular dysfunction[40,41] and specific biomechanical and sensory deficits at ankle level.[42,43] Somatosensory impairment in cervicogenic headache is likely caused by dysfunction in the upper cervical structures, which are known to have high proportions of proprioceptors providing information that is important for postural control.[15,16] Altered cervical afferent input and a mismatch between convergence of sensory inputs from altered cervical proprioceptors and normal sensory input from other subsystems (ie, visual and vestibular systems) can lead to altered postural stability.[44]

Migraine

The results of the current study, which demonstrated impaired standing balance in participants with migraine compared to asymptomatic controls, support previous studies.[21,45,46] However, definitive conclusions regarding possible mechanisms are limited by symptomatic characteristics and methodologic discrepancies between the studies. It has been suggested that balance impairment in those with migraine may be due to dizziness.[21] Patients with migraine often have difficulty with gaze stabilization and more visual dependence in order to maintain balance.[47] The results of the current study do not necessarily support this, since deficits in balance were seen in both eyes-open and eyes-closed positions. Additionally, patients with chronic migraine could have associated subclinical lesions of the vestibular and cerebellar systems.[21,46] It was noted that of 24 participants with migraine in this study, about 33% had dizziness, but this was not significantly different from those with cervicogenic headache and it is beyond the scope of this study to determine the cause of the dizziness in these subjects. Interestingly, in contrast to the cervicogenic headache subjects, the majority of the differences in postural sway in the migraine subjects compared to controls were seen in the ML direction rather than the AP direction. This may support a vestibular component to postural stability deficits in this group, but more research as to the precise mechanisms of the balance disturbances in migraine is required.[40,41]

Comparison Between Cervicogenic Headache and Migraine

The overall results demonstrated some differences in the magnitude and direction of postural sway between the cervicogenic headache and migraine groups. The mean sway area in the condition of narrow stance with eyes closed on a soft surface was about 70% higher in the cervicogenic headache group than the migraine group. Furthermore, significantly higher AP_{max} and lower ML_{max} values were seen in selected tests in the cervicogenic group compared to the migraine group. Further research will be required to clarify the mechanisms behind these differences in postural stability disturbances between migraine and cervicogenic headache. Balance disturbance in cervicogenic headache seems similar to that in neck pain and likely reflects altered cervical afferent input to the sensorimotor control system as the main cause of the balance impairments found in the current study.[13,14] In contrast, differences in sway results in the current study suggest that somatosensory disturbances may not be the cause of balance disturbances in migraine and may rather reflect visual abnormalities or subclinical vestibular or cerebellar dysfunctions,[21,46] but more research is warranted. Also, it should be noted that the present migraine group had neck pain related to headache, which is consistent with previous studies.[1,48] However, the cervical musculoskeletal impairment was not objectively assessed in the migraine and asymptomatic control groups. While this would not be expected in these groups,[8] an objective examination was not performed, and thus it is uncertain whether postural instability in migraine is also associated with the presence of neck pain and impairment. Thus, these results should be interpreted with caution.

The results of this study also may have implications for the types of clinical interventions to address these impairments. This study explored static postural stability, but further studies are needed to further investigate dynamic balance and mobility in patients with cervicogenic headache and migraine, which may also be impaired. Sensorimotor training and postural control rehabilitation in individuals with headache associated with neck pain would also provide a better understanding of the role of the cervical spine in sensorimotor function.

Also, from a clinical perspective, clinical assessment and early management of balance impairment should be addressed in patients with cervicogenic headache and migraine. However, based on the findings of this study, specific tests of balance may need to be selected. The assessment of balance performance may help to decide those headache patients who may benefit from intervention to improve balance control and reduce risk of falls.

Limitations

There were some limitations in the present study. A diagnostic nerve block was not considered in the patients with cervicogenic headache; however, cervicogenic headache was identified according to the standard diagnostic criteria and physical impairments.[8,27] It could also be argued that patients with migraine might have some undiagnosed vestibular pathology. The study enrolled participants with migraine according to classification criteria of the IHS,[28] and it is possible that those with vestibular migraine were included. A heterogenous group of patients with migraine and lack of confirmation of absence of the cervical musculoskeletal impairment in both migraine and asymptomatic control groups were also potential limitations of the study. Postural instability in those with migraine may be partially influenced by neck pain and impairment. Dizziness may be a factor in the results, as both groups reported the presence of dizziness but none had dizziness on the testing day. However, the exact nature and intensity of the dizziness and differences between the groups were not explored in this study. Postural sway path length and speed were also not measured; this should be considered in future research.

Conclusions

The results of this study have demonstrated that individuals with cervicogenic headache and those with migraine had impaired standing balance compared to asymptomatic controls in selected tests. The balance deficits were considerably greater in the AP direction in cervicogenic headache and in both the AP and ML directions in migraine. The study suggests that individuals with cervicogenic headache and those with migraine have standing balance disturbances, but possibly to a different extent and pattern. The results indicate that balance tests should be assessed in patients with cervicogenic headache and migraine, especially in those who complain of unsteadiness; however, the conditions in which balance tasks are tested must be sufficiently challenging. The results may also indicate a different etiology in these headache types and suggest that different management approaches for the balance disturbances in those with cervicogenic headache and migraine may be required.

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The authors report no conflicts of interest.

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