Neck Muscle Stiffness Measured by Shear Wave Elastography in Patients with Cervicogenic Dizziness: A Case-Control Study

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ABSTRACT

Objective: To evaluate the neck muscle stiffness in patients with cervicogenic dizziness (CGD) using shear wave elastography (SWE).
Study Design: A case-control study.
Place and Duration of the Study: Department of Otorhinolaryngology, Van Yuzuncu Yil University, Van, Turkiye, from 2023 to 2025.
Methodology: The study included 33 patients with CGD and 33 matched healthy controls. Cervical muscle stiffness was measured by SWE in the sternocleidomastoid (SCM), trapezius (TRAP), splenius capitis (SPLC), and semispinalis capitis/cervicis (SCC) muscles. Neck pain, dizziness, neck disability, and dizziness handicap levels were also determined. Student's t-test and Mann-Whitney U test were used to compare muscle stiffness between the groups.
Results: CGD patients and the Control group were similar in terms of age, gender, and body mass index (BMI [kg/m^2]; $p > 0.05$). CGD patients had significantly higher stiffness values in SCM ($p = 0.029$) and TRAP ($p = 0.025$) muscles compared to the Control group. However, there was no significant difference in the stiffness scores of SPLC ($p = 0.199$) and SCC ($p = 0.681$) muscles between the groups. In CGD patients, a significant positive correlation between SPLC muscle stiffness and neck disability was observed. However, there was no significant correlation between cervical muscle stiffness and neck pain, dizziness, neck disability, or dizziness handicap.
Conclusion: SWE findings showed that CGD patients had higher SCM and TRAP stiffness than healthy controls. These findings may be useful for understanding CGD and for improving diagnosis, differential diagnosis, and treatment. However, this is a preliminary study on the subject, and further studies are warranted.

Key Words: *Cervical, Cervicogenic, Dizziness, Elastography, Neck pain, Neck muscles, Ultrasonography*.

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INTRODUCTION

Cervicogenic dizziness (CGD) is defined as a clinical condition characterised by the co-occurrence of dizziness and neck pain.[1] Studies have shown that CGD is a common type of dizziness,[2] and the most common subtype is proprioceptive form.[3] Although the aetiology and pathogenesis of CGD are not fully understood, several reasons affecting the cervical spine have been suggested, including trauma, inflammation, degeneration, and instability.[1,3] In the absence of a confirmed diagnostic sign or symptom, CGD remains a diagnosis of exclusion for clinicians.[1,3] Therapeutic management of CGD is similar to that of neck pain, with manual and exercise therapy being the most commonly recommended approaches.[3,4]

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Shear wave elastography (SWE) is recognised as a reliable tool for assessing the musculoskeletal system, offering objective, quantitative, and reproducible applications.[5] By determining the degree of tissue stiffness, SWE offers the possibility to assess both disease severity and treatment effectiveness.[5,6] In this way, various pathologies in the musculoskeletal system can be evaluated using SWE.[5] For example, high SWE scores, indicating increased muscle stiffness, have been shown to be associated with a higher frequency of injury.[6]

As the aetiopathogenesis and diagnostic criteria of CGD have not yet been clarified, it is important to investigate tools with the potential to resolve these uncertainties. Hypothetically, neck muscle stiffness, neck pain, proprioceptive dysfunction, and dizziness may be interrelated, and the possible interaction among these conditions in CGD warrants investigation. Theoretically, assessment of neck muscle stiffness using SWE may provide diagnostic findings and clarify the aetiopathogenesis of CGD. Furthermore, SWE may have the potential to assess both the disease severity and treatment effectiveness in CGD. Therefore, this study aimed to evaluate the neck muscle stiffness in patients with recurrent CGD using SWE.

METHODOLOGY

This case-control study was conducted with the approval of the Ethics Committee of Yuzuncu Yil University, Van, Turkiye (Decision No. 2019/07). However, due to COVID-19 pandemic, patient follow-up could not be fully carried out, and there were some losses in the 2019 data. Therefore, with the Ethics Committee approval for additional time, the study data were prospectively collected during routine outpatient clinic practice between 2023 and 2025. Each patient underwent a special, comprehensive clinical examination. In addition, a detailed patient history was obtained from each patient. To diagnose CGD, the cervical torsion test (CTT) was performed using Frenzel goggles. After excluding other peripheral and central causes, patients who tested positive were diagnosed with CGD. The CTT is recommended as the best method for the diagnosis of CGD.[3] A patient was seated on a swivelling chair during the CTT. During the test, the clinician fixed the patient's head while the patient rotated the trunk 90 degrees to the left and right, maintaining each position for 30 seconds before returning to the resting position. The intensity of nystagmus in the fixed and non-fixed head was compared, and nystagmus of more than two degrees per second was considered positive for CGD.

Inclusion criteria included complaints of dizziness and neck pain, pain on palpation in the neck region, neck muscle tension and tenderness, and restriction of cervical movement. All patients included in the study had no history of manoeuvres for dizziness, no history of ototoxic medicine use, and had normal hearing. To control for other variables affecting balance responses, such as degenerative disorders, only young adults aged 18-40 years with CGD, without systemic comorbidities, were included in the study.

Exclusion criteria included benign paroxysmal positional vertigo, Meniere's disease, migraine-associated vertigo, vertebrobasilar insufficiency, postural hypotension, history of cervical trauma, myofascial pain syndrome, fibromyalgia, and neurological, rheumatological and systemic diseases. Patients with neck-related conditions, such as MRI-detected cervical spondylosis, prominent cervical disc herniation, fracture, dislocation, spondylolisthesis, and cervical scoliosis, were also excluded from the study. Neurological consultation was requested for each patient. Patients with vascular pathology detected by vertebral and carotid artery Doppler ultrasonography were also excluded. Patients with central nervous system diseases, such as multiple sclerosis and degenerative diseases detected on cranial MRI, were excluded from the study. Patients with psychiatric disorders and a history of depression were also excluded.

SWE measurements were performed in CGD patients (n = 33) and in a matched healthy Control group (n = 33). Individuals in the healthy Control group were selected from the CGD patients' relatives and visitors. Written informed consent was obtained from each participant. The SWE assessment was performed by the same radiologist, who had 10 years of experience in elastography, using the acoustic radiation force impulse (ARFI)-based elastography option of the Virtual Touch IQ technology (Siemens Healthcare, Erlangen, Germany) and a 9L4 linear array transducer (frequency range: 4-9 MHz) in the sitting position. In the SWE procedure, all muscle structures were initially identified using grey-scale mode while the patient was seated and slightly leaning forward. In ARFI elastography, the patient was instructed to remain motionless throughout the measurements. During the measurement, the transducer was gently pressed onto the skin by the radiologist, and the target area was determined using ultrasonographic (USG) elastography. Two windows were created on the screen through the dual-display button. In the window on the left, small boxes showing the shear wave velocity in metres per second were placed in the effusion area of the region of interest, which was colour-coded in shades of grey. In the window on the right (grey-scale USG), it was ensured that the boxes were placed in the correct area (Figure 1). The average shear wave velocity was calculated using the velocity values obtained from the areas of interest. At least 8-12 measurements were obtained in each area. In this way, cervical extensor muscle stiffness was measured in the sternocleidomastoid (SCM), trapezius (TRAP), splenius capitis (SPLC), and semispinalis capitis/cervicis (SCC) muscles.

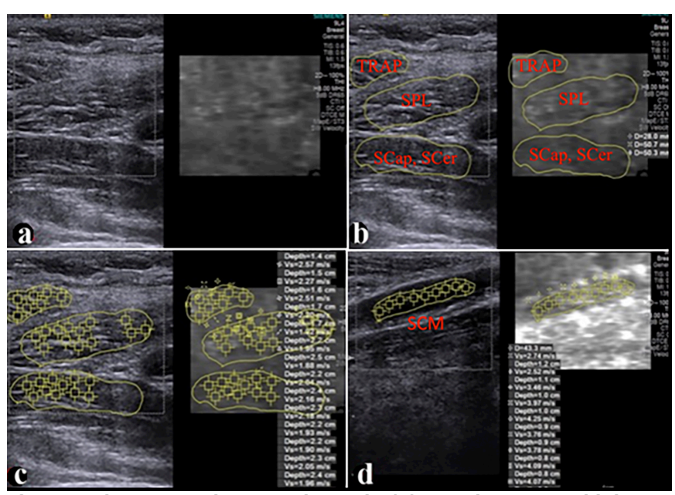

Figure 1: Shear wave elastography mode. (a) B-mode sonographic image of the upper TRAP, middle SPLC, and lower SCC. (b) Marking of the sample area. (c) Boxes showing elastographic measurements within these areas. (d) Marking and measurement of the sternocleidomastoid (SCM) sample area.

In addition, questionnaires included demographic information, a VAS for neck pain, the Neck Disability Index (NDI),[7] a VAS for dizziness, and the Dizziness Handicap Inventory (DHI)[8] were administered to the patients.

The data of CGD patients and the Control group were statistically compared. Statistical analyses were performed using IBM® SPSS® version 27. The Shapiro-Wilk test was used to evaluate the normality of the data for CGD patients (n = 33) and the Control group (n = 33). Based on the results of the normality test, the Student's t-test was used to compare variables showing a normal distribution, and the Mann-Whitney U test was used to compare variables showing a skewed distribution. The Pearson test and Spearman test were used to determine the statistical significance of correlations.

Table I: Demographics characteristics between CGD patients and the Control group.

Variables	CGD Patients (n = 33)	Control Group (n = 33)	p-values
Age (year)	30.88±4.50	30.03 ± 5.67	0.503[a]
Female/Male, n (%)	24 (72.7) / 9 (27.3)	24 (72.7) / 9 (27.3)	>0.99[b]
BMI (kg/m^2)	23.88 (4.50)	24.22 (5.29)	0.564[c]
VAS (dizziness)	7.0 (2.5)	-	-
VAS (neck pain)	6.0 (3.0)	-	-
DHI	45.61 ± 3.90	-	-
NDI	25.70 ± 6.25	-	-

[a]Student's t-test; [b]Chi-square test; [c]Mann-Whitney U test; CGD: Cervicogenic dizziness; VAS: Visual analogue scale; DHI: Dizziness handicap inventory; NDI: Neck disability index.

Table II: Comparison of muscle stiffness between CGD patients and the Control group.

Variables	CGD Patients (n = 33)	Control Group (n = 33)	p-values
SCM	3.56 (0.97)	3.28 (0.64)	0.029[a]
TRAP	3.54 (0.89)	2.99 (0.98)	0.025[a]
SPLC	3.83 ± 0.79	4.05 ± 1.02	0.199[b]
SCC	4.32 (1.07)	4.32 (1.0)	0.681[a]

[a]Mann-Whitney U test; [b]Student's t-test; SCM: Sternocleidomastoid; TRAP: Trapezius; SPLC: Splenius capitis; SCC: Semispinalis capitis/cervicis.

Table III: Correlation between muscle stiffness and other parameters in CGD patients.

Variables	SCM	TRAP	SPLC	SCC
VAS (dizziness)[a]	0.033	0.116	0.187	-0.149
	0.854	0.521	0.298	0.408
VAS (neck pain)[a]	-0.040	0.199	-0.024	-0.229
	0.824	0.266	0.895	0.200
DHI[b]	0.103	0.127	-0.236	-0.109
	0.570	0.480	0.186	0.547
NDI[b]	0.010	0.291	0.541	-0.125
	0.957	0.100	0.001*	0.488

[a]Spearman test; [b]: Pearson test; SCM: Sternocleidomastoid; TRAP: Trapezius; SPLC: Splenius capitis; SCC: Semispinalis capitis/cervicis; Correlations are given as r and p values.

For parametric tests, data were presented as mean ± SD, while for non-parametric tests, data were presented as median (IQR). For the Chi-square test, data were reported as frequencies. A p-value <0.05 was considered statistically significant.

RESULTS

Demographic characteristics and clinical features are presented in Table I. CGD patients and the Control group were found to be statistically similar in terms of age (p = 0.503), gender (p> 0.99), and body mass index (BMI: kg/m^2; p = 0.564). The mean age scores in CGD patients and the healthy controls were 30.88 ± 4.50 and 30.03 ± 5.67, respectively. Women constituted the majority of CGD patients, (72.7%), as shown in Table I.

When cervical extensor muscle stiffness measured by SWE was analysed, CGD patients were found to have significantly higher stiffness scores in the SCM (median 3.56 *vs*. 3.28; p = 0.029) and TRAP (median 3.54 *vs*. 2.99; p = 0.025) muscles compared to the Control group. However, no significant difference was found between CGD patients and the Control group in terms of stiffness scores in the SPLC (p = 0.199) and SCC (p = 0.681) muscles (Table II).

In CGD patients, there was a significant positive correlation between the SPLC muscle stiffness and the NDI (r: 0.541 and p = 0.001). Apart from this, no significant correlation was found between the cervical extensor muscle stiffness and the VAS (dizziness), VAS (neck pain), DHI, or NDI scores (p >0.05; Table III).

DISCUSSION

In this case-control study, CGD patients were compared with a matched healthy Control group in terms of cervical extensor muscle stiffness measured by SWE. Statistical comparison showed that CGD patients had higher SCM and TRAP stiffness than the Control group. However, CGD patients and the Control group were similar in terms of SPLC and SCC stiffness. These are preliminary findings and may be useful to understand the pathophysiology of CGD and to improve diagnosis, differential diagnosis, and treatment.

There is a complex interaction between cervical muscle stiffness, neck pain, proprioceptive dysfunction, and dizziness,[3,9] suggesting that more research is needed on neck-related dizziness. According to the present findings, 72.7% of CGD patients were female. Given that those with CGD characteristics, such as neck pain and headaches, are predominantly female[10] and considering that female gender is associated with weaker neck muscles,[11] CGD may be related to a cycle of pain, spasm, stiffness, and weakness in the neck muscles.

This study provides some evidence that supports an association between CGD and cervical muscle stiffness. CGD may represent dizziness induced by abnormal proprioceptive inputs caused by increased cervical muscle stiffness. This occurs because changes in the neck muscles are associated with abnormal sensorineural and proprioceptive signals that can lead to dizziness.[3,9]

To date, no studies have been conducted on the neck muscle stiffness using SWE in CGD patients. Therefore, it is not currently possible to compare the present findings with those reported in the literature. However, previous studies have addressed neck muscle stiffness measured by SWE in patients with chronic neck pain.[12-14] Similar to the present results, these studies found that the cervical extensors, especially the TRAP, showed greater stiffness in patients with neck pain compared to asymptomatic controls. Given that neck pain is associated with proprioception[15] and CGD,[1] the SWE findings reported in patients with neck pain can be considered and discussed in this study.

In addition, previous studies have examined the neck muscle stiffness measured by SWE in patients with cervicogenic headache.[16-18] Consistent with the present study, these studies found increased stiffness of the cervical extensor muscles in patients with cervicogenic headache compared to healthy controls. Given that cervicogenic headache is associated with neck pain,[10] similar to CGD,[1] it is reasonable to consider SWE findings from patients with neck pain in this study. Furthermore, SWE has been shown to serve as a diagnostic tool for neck somatic dysfunction and as an objective method for assessing treatment effectiveness,[19] thereby suggesting its potential of SWE in CGD.

According to the results of the present study, no association was found between cervical extensor muscle stiffness and the severity of dizziness or neck pain. However, an association was observed between SPLC stiffness and NDI. These results support previous reports indicating that the severity of pain and disability in patients with neck pain is not related to neck muscle stiffness.[10] Conversely, the present results are inconsistent with the established understanding that CGD is strongly associated with the severity of neck pain.[20] Indeed, such inconsistencies among SWE findings in musculoskeletal pain conditions have been noted previously and are attributed to methodological differences.[21]

This study has both strengths and limitations. It has high originality, as it is the first to specifically address this subject. However, the depth of the discussion is limited due to the lack of directly relevant data in the literature. Additionally, the case-control design limits the study's ability to reveal causal relationships. Finally, being a single-centre study conducted within a limited age range reduces the generalisability of the results.

CONCLUSION

SWE findings showed significantly increased stiffness in the SCM and TRAP muscles, while SPLC stiffness was associated with CGD intensity. These findings may help facilitate diagnosis, differential diagnosis, and treatment processes in patients with CGD. However, these are preliminary findings, further studies are required.

ETHICAL APPROVAL:
Ethical approval was obtained from the Ethics Committee of Van Yuzuncu Yil University, Van, Turkiye (Decision No. 2019/07). All procedures were performed in accordance with relevant guidelines and regulations and with the 1964 Declaration of Helsinki and its subsequent amendments or similar ethical standards.

PATIENTS' CONSENT:
Written informed consent was obtained from all the study participants.

COMPETING INTEREST:
The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:
YSC, SA, MO: Conceived and designed the study.
YSC, MO: Contributed to data acquisition.
SA, MO: Contributed to data analysis.
YSC, SA: Contributed to drafting and revision of the manuscript.
All authors approved the final version of this manuscript.

REFERENCES

1. Reiley AS, Vickory FM, Funderburg SE, Cesario RA, Clendaniel RA. How to diagnose cervicogenic dizziness. *Arch Physiother* 2017; **7**:12. doi: 10.1186/s40945-017-0040-x.
2. Takahashi S. Importance of cervicogenic general dizziness. *J Rural Med* 2018; **13(1)**:48-56. doi: 10.2185/jrm.2958.
3. Li Y, Yang L, Dai C, Peng B. Proprioceptive cervicogenic dizziness: A narrative review of pathogenesis, diagnosis, and treatment. *J Clin Med* 2022; **11(21)**:6293. doi: 10.3390/jcm11216293.
4. De Vestel C, Vereeck L, Reid SA, Van Rompaey V, Lemmens J, De Hertogh W. Systematic review and meta-analysis of the therapeutic management of patients with cervicogenic dizziness. *J Man Manip Ther* 2022; **30(5)**:273-83. doi: 10.1080/10669817.2022.2033044.
5. Taljanovic MS, Gimber LH, Becker GW, Latt LD, Klauser AS, Melville DM, *et al*. Shear-Wave elastography: Basic physics and musculoskeletal applications. *Radiographics* 2017; **37(3)**:855-70. doi: 10.1148/rg.2017160116.
6. Cummings P, Schilaty ND, Nagai T, Rigamonti L, Ueno R, Bates NA. Application of shear-wave elastography in the evaluation of hamstring stiffness in young basketball athletes. *Int J Sports Phys Ther* 2022; **17(7)**:1236-48. doi: 10.26603/001c.55757.
7. Kesiktas N, Ozcan E, Vernon H. Clinimetric properties of the Turkish translation of a modified neck disability index. *BMC Musculoskelet Disord* 2012; **13**:25. doi: 10.1186/1471-2474-13-25.

8. Canbal M, Cebeci S, Duyan GC, Kurtaran H, Arslan I. A study of reliability and validity for the Turkish version of dizziness handicap inventory. *Turk J Family Med Prim Care* 2016. doi: 10.5455/tjfmpc.198514.
9. Sung YH. Suboccipital muscles, forward head posture, and cervicogenic dizziness. *Medicina (Kaunas)* 2022; **58(12)**: 1791. doi: 10.3390/medicina58121791.
10. Delen V, Ilter S. Headache characteristics in chronic neck pain patients with loss of cervical lordosis: A cross-sectional study considering cervicogenic headache. *Med Sci Monit* 2023; **29**:e939427. doi: 10.12659/MSM.939427.
11. Pardos-Aguilella P, Ceballos-Laita L, Cabanillas-Barea S, Perez-Guillen S, Ciuffreda G, Jimenez-del-Barrio S, *et al*. Correlation between neck muscle endurance tests, ultrasonography, and self-reported outcomes in women with low cervical disability and neck pain. *Applied Sciences* 2023; **13(18)**:10106. doi: 10.3390/app131810106.
12. Tas S, Korkusuz F, Erden Z. Neck muscle stiffness in participants with and without chronic neck pain: A shear-wave elastography study. *J Manipulative Physiol Ther* 2018; **41(7)**:580-8. doi: 10.1016/j.jmpt.2018.01.007.
13. Dieterich AV, Yavuz US, Petzke F, Nordez A, Falla D. Neck muscle stiffness measured with shear wave elastography in women with chronic nonspecific neck pain. *J Orthop Sports Phys Ther* 2020; **50(4)**:179-88. doi: 10.2519/jospt.2020.8821.
14. Opara M, Kozinc Z. Which muscles exhibit increased stiffness in people with chronic neck pain? A systematic review with meta-analysis. *Front Sports Act Living* 2023; **5**: 1172514. doi: 10.3389/fspor.2023.1172514.
15. Yilmaz K, Sert OA, Unuvar BS, Gercek H. Comparison of head posture and neck proprioceptive sense of individuals with chronic neck pain and healthy controls: A cross-sectional study. *J Back Musculoskelet Rehabil* 2024; **37(6)**: 1705-13. doi: 10.3233/BMR-240155.
16. Sedlackova Z, Vita M, Herman J, Furst T, Dornak T, Herman M. Elasticity of neck muscles in cervicogenic headache. *Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub* 2022; **166(3)**:328-33. doi: 10.5507/bp.2021.030.
17. Tavakkoli M, Bahrpeyma F. Elastic modulus of suboccipital muscles, cervical range of motion, and forward head posture in cervicogenic headache. *J Biomed Phys Eng* 2023; **13(5)**:463-70. doi: 10.31661/jbpe.v0i0.2104-1298.
18. Lin LZ, Yu YN, Fan JC, Guo PW, Xia CF, Geng X, *et al*. Increased stiffness of the superficial cervical extensor muscles in patients with cervicogenic headache: A study using shear wave elastography. *Front Neurol* 2022; **13**: 874643. doi: 10.3389/fneur.2022.874643.
19. Gao J, Lynch E, Coleman M, Moore J, Park D, Wilde B. Ultrasound shear wave elastography to assess neck somatic dysfunction and OMT effects. *J Osteopath Med* 2025. doi: 10.1515/jom-2024-0236.
20. Mb RS, Nedison G, Garcia CB. Clinical evaluation of neck in patients with proprioceptive cervicogenic dizziness. *Int Tinnitus J* 2022; **25(2)**:143-8. doi: 10.5935/0946-5448.20210026.
21. Haueise A, Le Sant G, Eisele-Metzger A, Dieterich AV. Is musculoskeletal pain associated with increased muscle stiffness? Evidence map and critical appraisal of muscle measurements using shear wave elastography. *Clin Physiol Funct Imaging* 2024; **44(3)**:187-204. doi: 10.1111/cpf.12870.