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Correlation between bruxism and cervical function

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Abstract

Background Temporomandibular joint has biomechanical and neurological interactions with cervical region in a complex functioning that is addressed as cranio-cervical mandibular system.

Subjects and methods In a prospective cohort study of 67 patients, their mean age 24.3 ± 5.6 years of both genders with temporomandibular disorder "bruxism," patients had fulfilled a questionnaire regarding bruxism manifestations. Pain pressure algometer was used to assess pain pressure threshold for trigger point in masseter, temporalis, sternocleidomastoid, and trapezius, and bubble inclinometer was used to assess cervical proprioception for all cervical ranges.

Results There was a statistical significant indirect weak correlation between proprioception error of cervical flexion and pain pressure threshold of masseter ($r = -0.333$) ($p = 0.006$), between proprioception error of cervical flexion and pain pressure threshold of trapezius ($r = -0.363$) ($p = 0.003$), and also between proprioception error of cervical left-side bending and pain pressure threshold of trapezius ($r - 0.298$; p 0.014), while there was significant direct weak correlation between proprioception error of cervical left rotation and cervical bending to left (r 0.315; p 0.009), where the p-value was < 0.05.

Conclusion The study proved that temporomandibular joint pain was correlated with impaired neck proprioception in whom with bruxism.

Trial registration NCT05657353. Registered 28 November 2022 — prospectively registered, https://register.clinicaltrials.gov/prs/app/action/LoginUser?ts=1&cx=-jg9qo4.

Keywords Temporomandibular disorder, Bruxism, Cervical pain, Pain pressure algometer, Cervical proprioception, Bubble inclinometer

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Introduction

Temporomandibular disorders (TMDs) include painful temporomandibular joint (TMJ) dysfunction or masticatory musculatures. Masticatory system functional role includes both speaking and chewing, where its muscular hyperactivity "parafunctional" is required for teeth grinding and/or clenching, i.e., bruxism [1, 2]. Recently, many authors had stated that masticatory system pain has close interaction with cervical disorders and vice versa [3].

Bruxism is recognized as oral unconscious dysfunctional rhythmic habit of teeth clenching, grinding, or pressing either throughout mastication resulting in traumatic occlusion [4] and/or while thrusting or mandibular bracing, and double particular circadian features take place during daylight or nighttime [5]. No doubt, bruxism aggravates pathological wear of tooth, periodontal lesions, and even TMD [6].

This is multifactorial etiologies with critical value for underlying pathomechanics for genesis, i.e., pathophysiological (central), peripheral (morphological), and psychosocial factors. Current additional focus on various bruxism either wakefulness or nighttime forms those rarely differentiated academically due to almost examining together and also recognition under the same medical term [1, 7].

Manfredini et al. reported the estimated wide bruxism prevalence range 8–31.4% [8]. A reduced bruxism prevalence correlation with aging, with 5–30% prevalence, was addressed for day-light bruxism, where 8–16% was reported for night bruxism [9], and reported 26–66% of bruxism complaint among TMD population [10].

According to the grading system, there are three states of bruxism: "possible bruxism" is the lowest diagnostic category, denoted by pain in the TMJ with maximal opening. The more advanced diagnosis category is "probable bruxism," which combines contralateral laterotrusion and TMJ pain during maximal mouth opening. When there is silent TMJ arthritis, severe arthritis with disturbance in growth or damage to the structure but without pain that cannot be identified by clinical examination, it is called "definite bruxism," the highest diagnostic level [11].

These are possible (based only on a self-report), probable (based on a clinical findings with or not a self-report), and definite (based on an instrumental examination, with or not a self-report and also a clinical finding) [12, 13].

There is an extensive link between TMJ and cervical region via anatomical, biomechanical and neurophysiological relation. Biomechanical bases ensured that additional jaw either closure or opening requires extra flexed or extended neck with interaction between trigeminal and cervical motor patterns among healthy population; thus, no doubt any related restrictions lead to vice versa impacts [14]. Neurophysiological explanations enhance mutual influences between cervical and jaw under upper cervical afferents' convergence, those addressed as neck sensory inputs (C1, C2, and C3) and trigeminal mandibular branch that is recognized as trigeminocervical complex (TCC). Due to TCC convergence central restrictions for interpreting specification of original source, so particular pathology at one area may affect the other [15, 16].

There were many studies that reported other methods to assess TMJ pain and cervical proprioception, and Alstergren et al. reported using visual analog scale [VAS] and numerical rating scale to assess TMJ pain severity [11]. Menabde et al. reported that the "UPAT" (Universal Pain Assessment Tool) was addressed as an investigating tool for ensuring restricted jaw function and pain among TMD individuals [17]. Another study by Gucmen et al. demonstrated that commonest cervical positional error test is laser pointer for clarifying proprioceptive affection [18]. As well, Reddy et al. reported that cervical range of motion (CROM) device validity for quantifying proprioceptive errors [19].

There was a gap in literature concerning relation between bruxism and cervical function by using pain pressure algometer for pressure pain threshold evaluation and bubble inclinometer for assessing cervical proprioceptive sense. Therefore, the present trial is attempted to examine bruxism impacts and its relation with cervical function.

Methods

Participants

Sixty-seven participants of both genders, diagnosed with bruxism, were recruited for current study from the outpatient clinic of health unit in 6th of October City, and IPC clinic, Giza, Egypt, through a period from December 2022 to April 2023.

Patients were enrolled according to bruxism questionnaire; their age range was 18–30 years old, because the temporomandibular pain occurs in about 10% of the population over than 18 years, and its prevalence is more in middle-aged adults [13, 16], with BMI 18–25 kg/m^2. Criteria for inclusion were clenching, grinding or associated sounds for bruxism, or even discomfort jaw musculatures or painful complains at ear front, jaw, or temple, and those influence motion or jaw functioning and pain in the temporalis or masseter muscles [20]. Criteria for exclusion were traumatic facial history or undergone any orthodontic management, pulsatile tinnitus, or degenerative lesions, as well as TMJ systematic articular arthritis or osteoarthritis, and muscular lesions, and/ or neurologic disorder involving trigeminal neuralgia, in addition to any neck or head malignancies were excluded from this study [20, 21].

G*Power software (3.0.10 version) was used for calculating size of current study sample via correlation bivariate normal model. The sample size was calculated using the G*Power software (version 3.0.10). Correlation Bivariate normal model was selected. Considering a power of 0.80, (one tail) and correlation p H1 0.3, one group, a generated sample size of 67.

Human participant clinical trial has complied with all national relevant rules and institutional procedures, and it has been approved by the Faculty of Physical Therapy Ethical Committee, Cairo University (No.: P.T.REC/012/003843). Registration of clinical trials is as follows: NCT05657353. Each participant has been assigned a consent form, initially. Also, measurements were done for once. The patients were assessed by using pain pressure algometer for pain pressure threshold and using bubble inclinometer for cervical proprioception.

Assessment procedures

Bruxism questionnaire

Questionnaires are being the most commonly used method because it is not expensive as other methods [22]. Bolarina has stated its validity and reliability for clinical and academic purposes [23]. For checking possible bruxism, initial participant awareness for bracing, clenching, or thrusting meaning is easily recognized by touching the teeth for non-swallowing target. After then, the patient is asked to keep an eye on their behavior for a week or two, therefore recorded participant response regarding bruxism [24].

Use two self-reporting questionnaires as follows: categorical participants' response "I do not know, No or Yes." For questionnaire 1, positive result bruxism for positive responded to first couple of questions or one of them with at least one manifestation enumerated by third question. For questionnaire 2, positive bruxism for double response of four questions [25].

Pain pressure algometer

It is used for the measurement of pressure pain threshold (PPT) for the trigger points of muscles [26], e.g., temporalis, masseter, sternocleidomastoid, and upper trapezius. Pressure pain thresholds were used to evaluate the mechanosensitivity of the orofacial structures, masticatory muscles, and cervical muscles [16]. Knapstad et al. ensured the validity and reliability of algometer tool for pressure pain threshold in evaluating of muscular trigger points [27].

Well-supported participant sat on a chair with hands over knees' top, with forehead facing forward. During assessment, perpendicular algometer placement, plus instructed participant for immediate response for initial pain, felt to applied pressure. Three repetitions were conducted with a 30-s interval and then recorded the average [28].

Bubble inclinometer for cervical proprioception

It is used for examining cervical proprioceptive sense using both target head position (THP) and neutral head position (NHP) [29]. Vafadar has reviewed that the inclinometer joint position sense (JPS) measurement method is reliable and valid [30].

The inclinometer was set at zero, and the participant sat on a chair with lower extremities bent at 90° and both feet on the ground with closed eyes for THP/NHP in flexion, extension, and bilateral side bending and then in supine for bilateral rotation THP. Looking straight ahead, the bubble inclinometer was strapped in place just above the ear for flexion/extension THP [31], for flexion/extension THP, on forehead center for bilateral side bending, and overhead vertex for bilateral rotation THR [32].

To evaluate THP, participants were checked couple of times for exact adopting of flexion and extension at 35°, bilateral lateral flexion at 30°, and bilateral rotation of 45° with clear orientation for neutral neck positioning in a passive maneuver. Then, each participant has to remember and adopt each position mentioned across active approach without instructions from the therapist. Three repetitions for THP test per each position were recorded, and the difference between each position's measured and correct values was in degrees [33]. And sustained for 3 seconds, the subjects received neither verbal nor visual feedback Throughout the test [32].

Statistical analysis

Pearson correlation coefficient relation used for parametric data (cervical pain) and Spearman correlation coefficient were used for nonparametric data (proprioception) to determine the relation between variables in bruxer patients. SPASS Inc. version 20 for PC Statistical Package for Social Sciences computer program (Chicago, IL, USA) was used. $P \leq 0.05$ was recognized as significant.

Results

Demographic features

Whole 67 participants demographic analysis revealed their age mean value was 24.3 ± 5.6 years, weight mean value was 63.4 ± 7 kg, height mean value was 164.7 ± 7 cm, and body mass index (BMI) mean value was 23.3 ± 1.6 kg/m^2. Males number was 27 (40.3%), and females were 40 (59.7%) as shown in Table 1.

Table 1 Participant's characteristics

Variable	Mean ± SD
Age (years)	24.3 ± 5.6
Weight (kg)	63.4 ± 7
Height (cm)	164.7 ± 7
BMI (kg/m^2)	23.3 ± 1.6
Sex distribution	Number (%)
Males	27 (40.3%)
Females	40 (59.7%)

Normality test

Data were screened for normality assumption, homogeneity of variance, and presence of extreme scores. Shapiro-Wilk and Kolmogrov-smirnov tests for normality showed that PPT variable is normally distributed, while Proprioception error of cervical movements is not normally distributed.

There was a statistical significant indirect weak correlation between proprioception error of cervical flexion and PPT of masseter "M1" ($r - 0.333$; p 0.006) (Fig. 1), between proprioception error of cervical flexion and PPT of trapezius "T1" ($r - 0.363$; p 0.003) (Fig. 2), and also between proprioception error of cervical left bending and PPT of trapezius "T1" ($r - 0.298$; p 0.014) (Fig. 3), unless there was obvious weak direct correlation of cervical proprioception error in left rotation with left bending (r 0.315; p 0.009) (Fig. 4) as shown in Table 2.

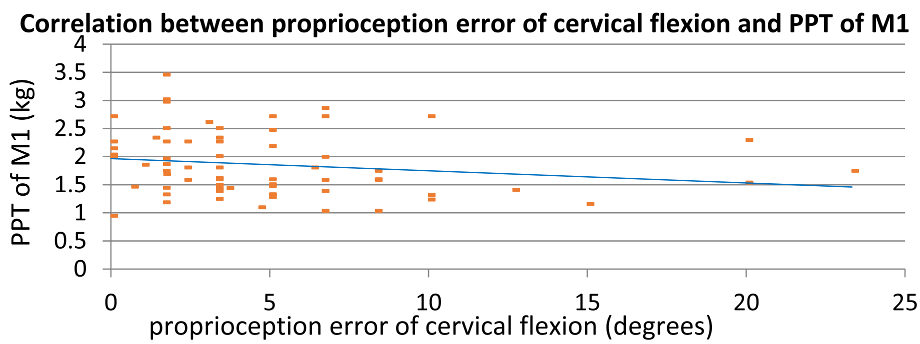

Fig. 1 Correlation between proprioception error of cervical flexion and PPT of M1

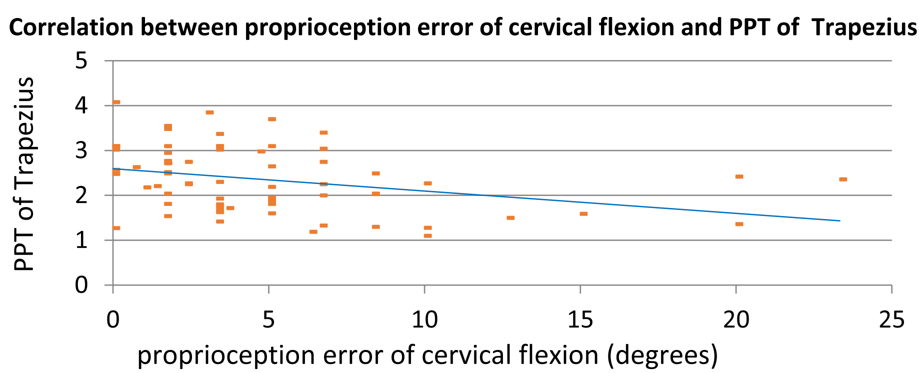

Fig. 2 Correlation between proprioception error of cervical flexion and PPT of trapezius

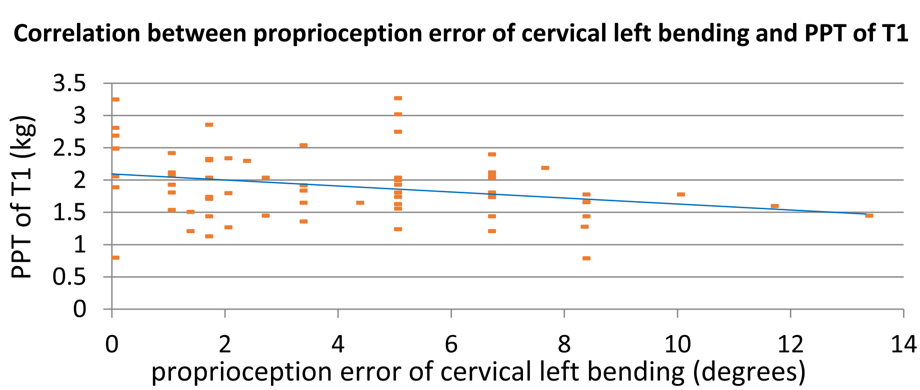

Fig. 3 Correlation between proprioception error of cervical left bending and PPT of T1

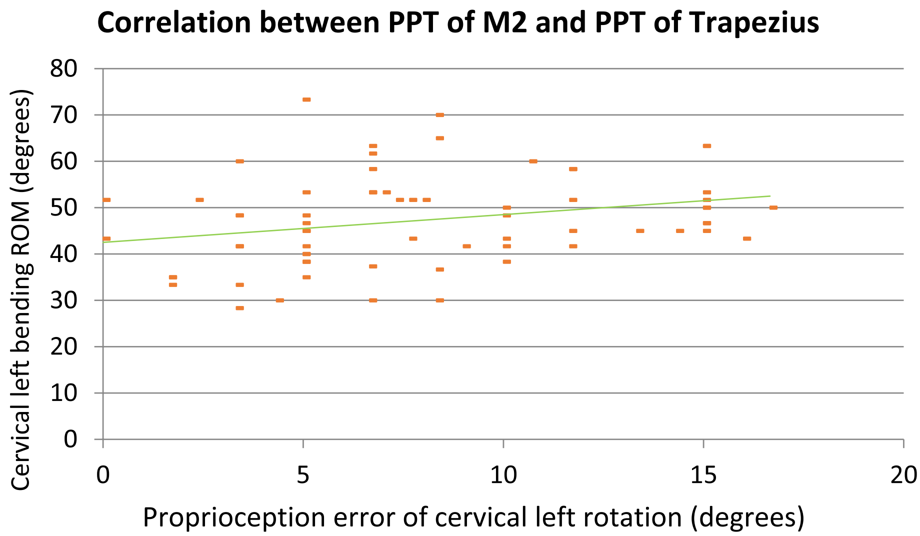

Fig. 4 Correlation between proprioception error of cervical left rotation and cervical left bending

Discussion

Current study focused on investigation of correlation between bruxism and cervical function by using pain pressure algometer for pressure pain threshold evaluation and bubble inclinometer for assessing cervical proprioceptive sense.

Anatomical, biomechanical, and neurophysiological evidence links the craniomandibular region and upper cervical spine; however, the neurophysiological relationship between both regions of the trigeminocervical nucleus may provide the most compelling explanation. The cervical region would become more sensitive to painful afferents from the temporomandibular region [16]. So, bruxism can decrease the threshold for pain in the orofacial and the cervical musculature and produce pain in the masticatory and cervical muscles [7].

Pain due to bruxism may take place at masticatory musculatures, or in cervical region or craniofacial complex, where painful hyperactive musculatures are due to existence of trigger points with taut bands. In addition, painful low orofacial or neck musculatures with bruxism could be explained by localized nociceptive hyperexcitability [7].

It has been postulated that abnormal cervical alignment may result in painful manifestations because of muscular imbalance within craniocervical area. It has also been postulated that the neck posture influences the mandibular position and both cervical musculatures and also masticator activities [34].

The increased magnitude of altered positional sense may be a negative pain impact based on painful chemical mediators; also, altered afferents form free neural endings, and those result in altered proprioceptive data. As well, many articles concluded that positive association between pain severity and elevated cervical proprioceptive sense errors [35], so pain, tissue damage, and degenerative joint conditions all depend on impaired proprioception [36].

Current trial findings agreed with [16] who evaluate neck impairment with TMD patients in relation to jaw impairment, craniocervical location, cervical alignment, and sensorimotor deficits; the findings demonstrated a correlation between cervical and mandibular disability in TMD patients, and [1] pointed out that increased tension in the masticatory muscles may be the cause of discomfort in the temporomandibular joints, cervical spine, and craniofacial region.

Also our study agreed with [37] which examined that a significant positive correlation between neck pain intensity and position sense and proved that extra painful complains was correlated with additional altered static cervical proprioceptive sense. Also, [38] found the relation which said that impaired cervical joint position sense among whom have painful neck complains. In addition, [36] had ensured that altered proprioceptive sense is a vital issue for persisted pain for degenerative or acute disorders.

But [37] mentioned that Lee et al. had investigated temporal pain aspects (frequency, intensity, and extend),

Table 2 Spearman correlation between joint position error and pain pressure threshold in Bruxer

		Cervical flexion	Cervical extension	Cervical right bending	Cervical left bending	Cervical right rotation	Cervical left rotation	PPT of T1	PPT of M1	PPT of M2	PPT of SM	PPT of trapezius
Error of flexion	***r*-value**	**−0.036**	**−0.021**	**0.032**	**−0.049**	**−0.028**	**−0.089**	**−0.188**	**−0.333**	**−0.420**	**−0.191**	**−0.363**
	***p*-value**	**0.773**	**0.863**	**0.796**	**0.693**	**0.820**	**0.476**	**0.128**	**0.006[a]**	**0.001[a]**	**0.121**	**0.003[a]**
Error of extension	*r*-value	0.006	0.091	0.073	0.105	0.142	0.062	0.028	0.123	0.037	0.083	−0.126
	p-value	0.595	0.465	0.559	0.397	0.251	0.616	0.820	0.323	0.766	0.503	0.309
Error of right bending	*r*-value	−0.116	0.038	−0.072	−0.081	−0.133	−0.104	−0.054	−0.023	−0.024	0.012	0.024
	p-value	0.350	0.762	0.562	0.513	0.285	0.404	0.666	0.853	0.850	0.923	0.850
Error of left bending	*r*-value	−0.067	−0.207	−0.138	0.010	−0.230	−0.021	−0.298	−0.225	−0.167	−0.128	0.072
	p-value	0.592	0.093	0.266	0.933	0.061	0.865	0.014[a]	0.067	0.177	0.304	0.562
Error of right rotation	*r*-value	−0.158	−0.009	−0.078	−0.022	−0.057	−0.014	−0.023	−0.048	0.033	0.239	0.019
	p-value	0.203	0.940	0.530	0.858	0.646	0.909	0.852	0.701	0.794	0.052	0.876
Error of left rotation	*r*-value	0.091	−0.065	0.223	0.315	0.112	0.122	0.062	0.109	0.013	0.074	0.047
	p-value	0.464	0.603	0.070	0.009[a]	0.367	0.368	0.619	0.381	0.920	0.551	0.705

[a] Correlation significant at the .05 level

correlating to sense of cervical position among subclinical individuals with cervical pain. Cervical pain severity did not reveal any consistent influence on cervical proprioceptive sense. Lee may not have consistently observed a relationship between each subject's pain severity and proprioceptive skill.

Conclusion

Bruxer subjects showed remarkable cervical joints' position errors in all tested directions. Hence, the current study revealed that elevated pain severity in bruxism was correlated to impaired proprioception and obvious cervical positional error in whom with bruxism.

Abbreviations

TMDs	Temporomandibular disorders
TMJ	Temporomandibular joint
TCC	Trigeminocervical complex
VAS	Visual analog scale
UPAT	Universal Pain Assessment Tool
CROM	Cervical range of motion
BMI	Body mass index
PPT	Pain pressure threshold
THP	Target head position
NHP	Neutral head position
JPS	Joint position sense
M1	Masseter
T1	Trapezius

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Authors' contributions

All authors worked together to develop the study's concept, gather data, plan, analyze data statistically, interpret data, write the analysis, and provide critical editing. The completed paper has been read and approved by the author(s).

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Availability of data and materials

Upon email request to the corresponding author, all study data and materials are accessible to interested researchers and journals.

Declarations

Ethics approval and consent to participate

Human participant clinical trial has complied with all national relevant rules and institutional procedures; it has been approved by Faculty of Physical Therapy Ethical Committee, Cairo University (No.: P.T.REC/012/003843). Each participant has been assigned a consent form, initially.

Consent for publication

The authors of the research provide their approval and note that no journals have received the study for publishing, and that it is not being considered for publishing in other journals.

Competing interests

The authors declare that they have no competing interests.

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References

1. Trukawka K, Gębska M, Mikołajczyk-Kocięcka A, Weber-Nowakowska K, Żyżniewska-Banaszak E. Assessment of neck disability index in people with bruxism. J Educ Health Sport. 2022;12(7):217–27. http://dx.doi.org/10.12775/JEHS.2022.12.07.021.
2. Reddy SV, Kumar MP, Sravanthi D, Mohsin AH, Anuhya V. Bruxism: a literature review. J Int Oral Health. 2014;6(6):105.
3. Guarda-Nardini L, Cadorin C, Frizziero A, Masiero S, Manfredini D. Interrelationship between temporomandibular joint osteoarthritis (OA) and cervical spine pain: effects of intra-articular injection with hyaluronic acid. Cranio. 2017;35(5):276–82. https://doi.org/10.1080/08869634.2016.1232788.
4. Demjaha G, Kapusevska B, Pejkovska-Shahpaska B. Bruxism unconscious oral habit in everyday life. Open Access Maced J Med Sci. 2019;7(5):876. https://doi.org/10.3889/oamjms.2019.196.
5. Vasundhara V. Sleep bruxism. Int J Med Oral Res. 2021;6(2):43–5. https://doi.org/10.4103/ijmo.ijmo_12_20.
6. Prabakaran P, Vishwas L, Nishanth MS. Wearing away; causes, diagnosis, prevention and management: a review. Int J Orl Health. 2022;2(1):1–7. https://doi.org/10.51626/ijoh.2022.02.00011.
7. Amorim CS, Vieira GF, Firsoff EF, Frutuoso JR, Puliti E, Marques AP. Symptoms in different severity degrees of bruxism: a cross-sectional study. Fisioter Pesqui. 2016;23(4):423–30. https://doi.org/10.1590/1809-2950/15988723042016.
8. Manfredini D, Winocur E, Guarda-Nardini L, Paesani D, Lobbezoo F. Epidemiology of bruxism in adults: a systematic review of the literature. J Orofac Pain. 2013;27(2):99–110. https://doi.org/10.11607/jop.921.
9. Beddis HP, Davies SJ. Relationships between tooth wear, bruxism and temporomandibular disorders. Br Dent J. 2023;234(6):422–6. https://doi.org/10.1038/s41415-023-5584-4.
10. Soares LG, Costa IR, Brum Júnior JD, Cerqueira WS, Oliveira ES, de Oliveira Douglas DW, et al. Prevalence of bruxism in undergraduate students. Cranio. 2017;35(5):298–303. http://dx.doi.org/10.1080/08869634.2016.1218671
11. Alstergren P, Pigg M, Kopp S. Clinical diagnosis of temporomandibular joint arthritis. J Oral Rehabil. 2018;45(4):269–81. https://doi.org/10.1111/joor.12611.
12. Manfredini D, Ahlberg J, Aarab G, Bracci A, Durham J, Ettlin D, et al. Towards a Standardized Tool for the Assessment of Bruxism (STAB)—overview and general remarks of a multidimensional bruxism evaluation system. J Oral Rehabil. 2020;47(5):549–56. https://doi.org/10.1111/joor.12938.
13. Baad-Hansen L, Thymi M, Lobbezoo F, Svensson P. To what extent is bruxism associated with musculoskeletal signs and symptoms? A systematic review. J Oral Rehabil. 2019;46(9):845–61. https://doi.org/10.1111/joor.12821.
14. Häggman-Henrikson B, Nordh E, Eriksson PO. Increased sternocleidomastoid, but not trapezius, muscle activity in response to increased chewing load. Eur J Oral Sci. 2013;121(5):443–9. https://doi.org/10.1111/eos.12066.
15. Ferreira MP, Waisberg CB, Conti PC, Bevilaqua-Grossi D. Mobility of the upper cervical spine and muscle performance of the deep flexors in women with temporomandibular disorders. J Oral Rehabil. 2019;46(12):1177–84. https://doi.org/10.1111/joor.12858.
16. Cuenca-Martínez F, Herranz-Gómez A, Madroñero-Miguel B, Reina-Varona Á, La Touche R, Angulo-Díaz-Parreño S, et al. Craniocervical and cervical spine features of patients with temporomandibular disorders: a systematic review and meta-analysis of observational studies. J Clin Med. 2020;9(9):2806. https://doi.org/10.3390/jcm9092806.
17. Menabde G, Janelidze M, Marks L. Use of the universal pain assessment tool for evaluating pain associated with TMD in youngsters with an intellectual disability. Med Oral Patol Oral Cir Bucal. 2017;22(1):e88. http://dx.doi.org/doi:10.4317/medoral.21584.
18. Gucmen B, Kocyigit BF, Nacitarhan V, Berk E, Koca TT, Akyol A. The relationship between cervical proprioception and balance in patients with fibromyalgia syndrome. Rheumatol Int. 2022;42(2):311–8. https://doi.org/10.1007/s00296-021-05081-1.
19. Reddy RS, Alahmari KA, Silvian PS. Test-retest reliability of assessing cervical proprioception using cervical range of motion device. Saudi J Sports Med. 2016;16(2):118. https://doi.org/10.4103/1319-6308.180174.
20. Blasco-Bonora PM, Martín-Pintado-Zugasti A. Effects of myofascial trigger point dry needling in patients with sleep bruxism and

temporomandibular disorders: a prospective case series. Acupunct Med. 2017;35(1):69–74. https://doi.org/10.1136/acupmed-2016-011102.
21. Peleg O, Haddad L, Kleinman S, Sella Tunis T, Wasserman G, Mijiritsky E, Oron Y. Temporomandibular disorders and bruxism in patients attending a tinnitus clinic. Appl Sci. 2022;12(10):4970. https://doi.org/10.3390/app12104970.
22. Koyano K, Tsukiyama Y, Ichiki R, Kuwata T. Assessment of bruxism in the clinic. J Oral Rehabil. 2008;35(7):495–508. https://doi.org/10.1111/j.1365-2842.2008.01880.x.
23. Bolarinwa OA. Principles and methods of validity and reliability testing of questionnaires used in social and health science researches. Niger Postgrad Med J. 2015;22(4):195–201. https://doi.org/10.4103/1117-1936.173959.
24. Lobbezoo F, Ahlberg J, Raphael KG, Wetselaar P, Glaros AG, Kato T, et al. International consensus on the assessment of bruxism: report of a work in progress. J Oral Rehabil. 2018;45(11):837–44. https://doi.org/10.1111/joor.12663.
25. Shinkaic RS. Concordance analysis between two questionnaires of self-reported. bruxism. 2018;59(1):24–9.
26. Slade GD, Sanders AE, Ohrbach R, Fillingim RB, Dubner R, Gracely RH, et al. Pressure pain thresholds fluctuate with, but do not usefully predict, the clinical course of painful temporomandibular disorder. J Int Assoc Study Pain. 2014;155(10):2134–43. https://doi.org/10.1016/j.pain.2014.08.007.
27. Knapstad MK, Nordahl SH, Naterstad IF, Ask T, Skouen JS, Goplen FK. Measuring pressure pain threshold in the cervical region of dizzy patients: the reliability of a pressure algometer. Physiother Res Int. 2018;23(4):e1736. https://doi.org/10.1002/pri.1736.
28. La Touche R, París-Alemany A, Von Piekartz H, Mannheimer JS, Fernández-Carnero J, Rocabado M. The influence of cranio-cervical posture on maximal mouth opening and pressure pain threshold in patients with myofascial temporomandibular pain disorders. Clin J Pain. 2011;27(1):48–55. https://doi.org/10.1097/AJP.0b013e3181edc157.
29. Treleaven J. Sensorimotor disturbances in neck disorders affecting postural stability, head and eye movement control. Man Ther. 2008;13(1):2–11. https://doi.org/10.1016/j.math.2007.06.003.
30. Vafadar AK, Côté JN, Archambault PS. Interrater and intrarater reliability and validity of 3 measurement methods for shoulder-position sense. J Sport Rehabil. 2016;25(1):234–9. https://doi.org/10.1123/jsr.2014-0309.
31. Zedan AM, Sarhan MA. Effect of shoulder stability exercises on cervical proprioception in patients with mechanical cervical and shoulder pain. Int J Multidiscip Res Dev. 2020;7(6):40–3.
32. Alahmari K, Reddy RS, Silvian P, Ahmad I, Nagaraj V, Mahtab M. Intra-and inter-rater reliability of neutral head position and target head position tests in patients with and without neck pain. Braz J Phys Ther. 2017;21(4):259–67. https://doi.org/10.1016/j.bjpt.2017.05.003.
33. Gong W. Effects of cervical joint manipulation on joint position sense of normal adults. J Phys Ther Sci. 2013;25(6):721–3.
34. Armijo-Olivo S, Rappoport K, Fuentes J, Gadotti IC, Major PW, Warren S, Thie NM, Magee DJ. Head and cervical posture in patients with temporomandibular disorders. J Orofac Pain. 2011;25(3):199–209.
35. Alahmari KA, Reddy RS, Tedla JS, Samuel PS, Kakaraparthi VN, Rengaramanujam K, Ahmed I. The effect of Kinesio taping on cervical proprioception in athletes with mechanical neck pain: a placebo-controlled trial. BMC Musculoskelet Disord. 2020;21(1):1–9. https://doi.org/10.1186/s12891-020-03681-9.
36. Reddy RS, Tedla JS, Alshahrani MS, Asiri F, Kakaraparthi VN. Comparison and correlation of cervical proprioception and muscle endurance in general joint hypermobility participants with and without non-specific neck pain: a cross-sectional study. PeerJ. 2022;10:e13097. https://doi.org/10.7717/peerj.13097.
37. Reddy RS, Tedla JS, Dixit S, Abohashrh M. Cervical proprioception and its relationship with neck pain intensity in subjects with cervical spondylosis. BMC Musculoskelet Disord. 2019;20(1):1–7. https://doi.org/10.1186/s12891-019-2846-z.
38. Alahmari KA, Reddy RS, Silvian P, Ahmad I, Nagaraj V, Mahtab M. Influence of chronic neck pain on cervical joint position error (JPE): comparison between young and elderly subjects. J Back Musculoskelet Rehabil. 2017;30(6):1265–71. https://doi.org/10.3233/BMR-169630.

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