Internet Journal of Allied Health Sciences and Practice

Volume 21 | Number 4 Article 16

September 2023

Occurrence of Temporomandibular Disorder in Subjects with Low Back Pain and Spinal Postural Deformities: An Observational Study

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Recommended Citation

Kage V, Welling A, Desai R. Occurrence of Temporomandibular Disorder in Subjects with Low Back Pain and Spinal Postural Deformities: An Observational Study. The Internet Journal of Allied Health Sciences and Practice. 2023 Sep 21;21(4), Article 16.

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Abstract

Purpose: Back pain and temporomandibular disorder (TMD) are two predominant illnesses that affect the human motor system. Literature has stated significant associations between chronic low back pain (CLBP) and TMD. Global postural deviations cause body adaptation and realignment, which may interfere with the function of TMJ. However, the possibility of TMD in subjects with CLBP associated with spinal postural deformities has yet to be completely explored. **Method:** This was an observational study carried out among 65 people having CLBP with co-presence of any spinal deformities. Forward head posture (FHP) was assessed using the On-Protractor application and thoracic kyphosis and lumbar lordosis were assessed using flexicurve. Those with co-occurrence of LBP and spinal deformity were further evaluated for the presence of TMD using Fonseca's questionnaire. The prevalence of TMD in LBP along with spinal deformities was analyzed and the variables were compared based on gender, age categories, and type of LBP (specific and non-specific). **Results:** The overall prevalence of TMD (mild, moderate, and severe) was 89.2% (n=58) in participants with low back pain and spinal postural abnormalities. The severity of FHP was more in specific LBP than in non-specific LBP, while the occurrence of TMD was equal. The severity of TMD was higher in females than males. **Conclusion:** The occurrence of TMD is highly prevalent in patients with low back pain and spinal postural deformities. The findings of the study imply that individuals with low back pain and spinal postural deformity should also be evaluated for TMJ dysfunction and initiate early intervention.

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Acknowledgements

We would like to thank the health minds firm for extending their help to perform statistical analysis of the data

IJAHSP™
The Internet Journal of Allied Health Sciences and Practice
Dedicated to allied health professional practice and education
Vol. 21 No. 4 ISSN 1540-580X

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ABSTRACT

Purpose: Back pain and temporomandibular disorder (TMD) are two predominant illnesses that affect the human motor system. Literature has stated significant associations between chronic low back pain (CLBP) and TMD. Global postural deviations cause body adaptation and realignment, which may interfere with the function of TMJ. However, the possibility of TMD in subjects with CLBP associated with spinal postural deformities has yet to be completely explored. **Method:** This was an observational study carried out among 65 people having CLBP with co-presence of any spinal deformities. Forward head posture (FHP) was assessed using the On-Protractor application and thoracic kyphosis and lumbar lordosis were assessed using flexicurve. Those with co-occurrence of LBP and spinal deformity were further evaluated for the presence of TMD using Fonseca's questionnaire. The prevalence of TMD in LBP along with spinal deformities was analyzed and the variables were compared based on gender, age categories, and type of LBP (specific and non-specific). **Results:** The overall prevalence of TMD (mild, moderate, and severe) was 89.2% (n=58) in participants with low back pain and spinal postural abnormalities. The severity of FHP was more in specific LBP than in non-specific LBP, while the occurrence of TMD was equal. The severity of TMD was higher in females than males. **Conclusion:** The occurrence of TMD is highly prevalent in patients with low back pain and spinal postural deformities. The findings of the study imply that individuals with low back pain and spinal postural deformity should also be evaluated for TMJ dysfunction and initiate early intervention.

Keywords: low back pain, forward head posture, kyphosis, lordosis, temporomandibular disorder, posture

INTRODUCTION

The jaw is a fundamental aspect of the human engine framework with a functional relationship with the head-neck motor system.[1] Temporomandibular disorder (TMD) is a term used to describe a specific group of painful orofacial conditions that affect the temporomandibular joint (TMJ) and associated muscles. Symptoms of TMD may include pain in the TMJ, fatigue of the muscles used for chewing, restricted movement of the mandible, and the presence of clicking sounds in the joint.[2] TMD signs are present in 50-75% of the population at some point in their lives.[3] Pain outside the TMJ and masticatory muscles, including pain at the neck/ cervical joint, and upper back, is predominant among TMD patients.[4.]

Low back pain has been linked to a variety of postural abnormalities including lumbar lordosis, thoracic kyphosis, and forward head posture.[5] A study conducted in Sweden found a significant association between long-term back pain and dysfunction/pain in the jaw and face.[6] It is suggested that this may be due to reflex connections caused by dysfunctional motor control, muscle stiffness, and discomfort. The co-occurrence of back pain and jaw-face pain may be influenced by non-specific effects of central pain processing and sensitization, however, there is uncertainty that surrounds the etiology of this identified sensory-motor abnormalities.[5-6]

TMD can also lead to changes in posture and muscle function, as the body tries to compensate for the pain and discomfort caused by the condition. The musculoskeletal system is made up of interconnected kinetic chains; any disruption to one segment will cause the rest of the system to reorganize.[7-8] One way that TMD can cause modifications in the body is by altering muscle activity and force distribution. Studies have shown that patients with TMD often exhibit changes in muscle activity patterns, such as increased activity in the neck and shoulder muscles, as well as alterations in the timing and sequence of muscle activation. These changes can lead to an imbalance in muscle force distribution, which can affect not only the jaw and neck but also the spine and other body regions.[9-10] Another way that TMD can cause modifications in the body is by altering posture and movement patterns[11]. Patients with TMD may adopt abnormal postures, such as a forward head posture, to reduce the strain on the jaw and neck muscles.[12-13] These postural changes can lead to compensatory movements and muscle activity patterns that can further exacerbate the condition.

It is important to study the relationship between poorly aligned body posture and the occurrence of TMD in individuals with chronic low back pain (CLBP) and spinal postural abnormality because the results could have significant implications for patient care. Specifically, if a clear link is established between these conditions, healthcare providers may need to consider screening patients with CLBP for TMD and vice versa, as well as incorporating postural correction strategies into their treatment plans. Furthermore, it is important to investigate this relationship of TMD in both specific and non-specific low back pain individuals because these two groups may have different underlying causes of their low back pain, and therefore may respond differently to postural correction strategies. Specifically, individuals with specific low back pain have a known structural cause for their pain (e.g., herniated disc), while those with non-specific low back pain do not have a clear underlying cause. Hence, the proposed study aims to determine the occurrence of TMD in subjects with chronic specific and non-specific low back pain with co-presence of spinal postural deformities. By establishing a clear relationship between poorly aligned body posture and TMD in individuals with CLBP and spinal postural abnormalities, this study could have significant implications for patient care and improve our understanding of the complex relationship between these conditions.

METHODS

This observational study was carried out where the study population was recruited from a tertiary health care center, in Belagavi, Karnataka. A total of 156 participants with chronic LBP who visited physiotherapy OPD between November and April 2021 were screened for spinal deformity. After screening 156 patients 65 individuals with chronic low back pain and co-presence of spinal postural deformity (forward head posture, thoracic kyphosis, and lumbar lordosis), aged between 20 to 65 years were included. However, individuals with generalized pain (Fibromyalgia), any orthodontic prosthesis, congenital and hereditary pathologies of the spine and TMJ, history of surgery of the spine, skeletal system fractures, previous TMD treatment over a period of 15 days, and those unwilling to participate in the study were excluded.

Flexicurve is a commonly used instrument for evaluating spinal postural deformities in patients with low back pain (LBP). Flexicurve is a flexible ruler that conforms to the contour of the spine, allowing for measurement of the curvature of the spine in the sagittal plane[14-15]. It is reliable and valid in assessing spinal postural deformities. Hence in the current study, the presence of thoracic kyphosis and lumbar lordosis were screened using a 61 cm Saurveyor's flexi curve. For this, a flexicurve was molded to the curve of the spine from C7-S1 and traced onto graph paper (Figure 1). The maximum width and total length of the curve were then measured using the formula $\theta° = 4 (\arctan [2H/L])$. To measure the degree of lordosis, a vertical line joining the T12 and S2 vertebrae was used, while a line joining C7 and T12 was used to measure the degree of kyphosis. The maximum width (i.e., the deepest part of the curvature) was denoted as H in the formula.

Figure 1. Flexicurve Molded to the Curve of the Spine

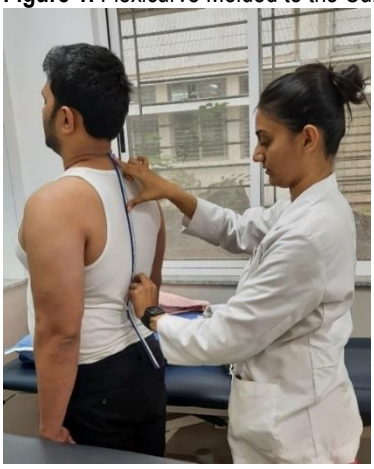
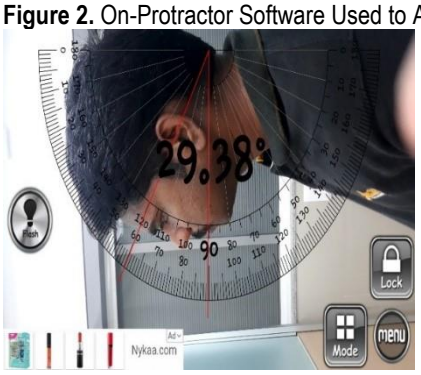


Figure 2. On-Protractor Software Used to Assess Forward Head Posture



On-Protractor is a software application that can be used to assess forward head posture. It is designed to measure the angle between the neck and shoulder using a digital protractor, which can provide an objective measure of the degree of forward head posture. There are several studies that have investigated the validity and reliability of using software applications for the assessment of forward head posture; however, they did not specifically investigate the validity and reliability of Protractor software. Supporting literature exists for the use of smartphone apps and digital protractors for assessing forward head posture.[16] Therefore, in this study, the presence of forward head posture/craniovertebral angle was assessed using a smartphone supported On-Protractor software application. To capture a lateral view of the participant's standing posture, a digital camera was mounted 1.5 meters away. The angle was measured at the juncture of a line drawn from the spinous process of C7 to the tragus of the ear and a horizontal line passing through C7. The postural deformities considered were thoracic kyphosis of >50 degrees,[17] lumbar lordosis> 45 degrees,[18] and cervical angle <53 degrees was considered abnormal.[19]

Those with the presence of spinal postural deformity were further evaluated for TMD using the Fonseca questionnaire. The Fonseca questionnaire is a validated and widely used instrument for assessing TMD.[20.] It consists of 10 questions that assess the severity of TMD symptoms, including pain, clicking or popping, limited opening, and joint locking. The questionnaire has been shown to have high reliability and validity in detecting TMD in various populations.[20-21] Patient-assisted Fonseca's questionnaire was used to assess TMD. This questionnaire is a functional assessment scale, which contains 10 questions to assess the presence of TMD. This questionnaire was used to categorize the severity of TMD. Interpretation of scores was as follows: 0–15 as No TMD, 20–40 as mild TMD, 45–65 as moderate TMD, and 70–100 as severe TMD.

The Modified Oswestry Disability Index (MODI) is a reliable and sensitive tool for assessing disability in individuals with low back pain. Its simplicity and wide usage make it a useful tool in both clinical and research settings.[22] MODI was used to assess the severity of chronic low back pain.

Data were analyzed using the statistical software **R 3.6.3**. The scores obtained were checked for their normality, showing that data was following normal distribution (Shapiro-Wilk test statistic). Mean and standard deviation was used to describe continuous

variables and categorical variables were expressed using frequencies and percentages. The difference in the mean of the Modified Oswestry Disability Index (MODI) score over specific low back pain (SLBP) and nonspecific low back pain (NSLBP) was analyzed using a two-sample t-test/ Welch's t-test. Comparative analysis between SLBP and NSLBP of thoracic curve angle, lumbar angle, craniovertebral angle, and Fonseca score were analyzed using Mann-Whitney's U test.

RESULTS

The analysis included responses from 65 participants with low back pain combined with spinal postural deformity aged between 20-65 years. In this study, 24 male and 41 female participants were included. Table 1A and 1B provide descriptive data and characteristics of the continuous and categorical variable.

Table 1A: Descriptive Statistics for Continuous Variables (n=65)

Variables	Mean ± SD
Age (years)	35.84±9.89
BMI(kg/m^2)	24.94±3.14
MODI Score	60.61±8.5
Craniovertebral Angle (Degrees)	50.95±9.02
Thoracic Curve Angle (Degrees)	53.55±10.88
Lumbar Curve Angle(Degrees)	51.58±8.85
Fonseca Score	45.63±17.48

SD: Standard deviation; BMI: Body Mass Index; MODI: Modified Oswestry Disability Index

Table 1B: Descriptive Statistics for Categorical Varaibles (n=65)

Varaibles	Characteristics	Frquency n (%)
Gender	Female	40 (61.53)
	Male	25 (38.46)
Cause of LBP	NSLBP	60 (92.30)
	SLBP	5 (7.69)
Age category (years)	20-40	47 (72.3)
	40-60	17 (26.15)
	>60	1 (1.53)

LBP: Low Back Pain; NSLBP: Non-Specific Low Back Pain; SLBP: Specific Low Back Pain

Table 2 shows the details of the occurrence of TMD, low back pain-related disability, and spinal postural deformities among 65 participants. In this study, according to the MODI questionnaire, about half of the total participants (53.8%) suffered from severe disabilities. Among the three spinal postural deformities that were considered in the study, the occurrence of forward head posture was highest (n = 27, 41.5%) followed by thoracic kyphosis (n=21, 32.4%) and least was with lumbar lordosis (n=17, 26.1%). Among participants with low back pain and spinal postural deformities, the occurrence of TMD was in 58 (89%) of people ranging from mild to severe TMD.

Table 2: Occurrence of TMD

Variables	Categories	Frequency (n=65)	Percentage (100%)
MODI score	Severe Disability	35	53.8
	Cripple, Pain impinges on all aspects of the patient's life	29	44.6
	Patients are bed-bound or exaggerating their symptoms	1	1.6
Spinal deformities	Forward head posture	27	41.5
	Thoracic kyphosis	21	32.4
	Lumbar Lordosis	17	26.1
Fonseca score	No TMD	7	10.8
	Mild TMD	15	23.1
	Moderate TMD	27	41.5
	Severe TMD	16	24.6

MODI: Modified Oswestry Disability Index; TMD: TemporoMandibular Dysfunction

The LBP subjects were categorized as specific low back pain (SPLB) and non-specific low back pain (NSLBP) based on the cause of pain and the data was analyzed for the occurrence of TMD, disability, and postural deformities among both categories. The severity of FHP was more in the SLBP group than in the NSLBP group ($p<0.05$). The severity of other postural deformities, back disability, and TMD was equal among both categories of LBP (Table 3).

Table 3: Between SLBP and NSLBP Category Analysis

Variables	SLBP	NSLBP	P-value
	Mean± SD	Mean± SD	
MODI score	65.6±6.1	60.2±8.57	0.12[wt]
Craniovertebral Angle	47.07±4.9	55.61±8.99	0.03*[MU]
Thoracic Curve Angle	53.54±10.61	53.55±10.99	0.89[MU]
Lumbar Curve Angle	50.67±14.19	51.82±8.39	0.72[MU]
Fonseca Score	43.2±21.06	45.83±17.34	0.88[MU]

**P value is <0.05; Wt: Welch's t-test; MU- Mann-Whitney U test; MODI: Modified Oswestry Disability Index; SLBP: specific low back pain; NSLBP: non specific low back pain*

The severity of the postural deformities and the disability were insignificant between male and female participants. However, the TMD severity was higher in females than in males (P=0.01). Among the age categories, LBP was more severe in > 41 years than in the participants in 20-40 years of age (P=0.0001). However, the severity of the postural deformities and TMD was equal among both age categories (Table 4).

Table 4: Comparative Analysis of the Variables Between Genders and Age Categories

Variables	Gender		*p*-value	Age category		P-value
	Female	Male		41-65 Years	20-40 Years	
MODI score	61.37±8.39	59.4±8.69	0.52 [MU]	66.44±8.6	58.38±7.4	0.0001* [MU]
Craniovertebral Angle	55.17±8.87	54.6±9.42	0.76 [MU]	55.47±10.3	54.75±8.59	0.97 [MU]
Thoracic Curve Angle	54.26±11.15	52.42±10.54	0.39 [MU]	53.71±10.29	53.49±11.2	0.64 [MU]
Lumbar Curve Angle	52.06±9.57	52.42±7.65	0.65 [MU]	51.05±8.54	51.79±9.04	0.76 [W]
Fonseca Score	50.02±14.65	38.6±19.55	0.01*[MU]	48.94±15.36	44.36±18.22	0.64[MU]

**Pvalue is <0.05; Wt: Welch's t-test; MU- Mann-Whitney U test; MODI: Modified Oswestry Disability Index*

DISCUSSION

The overall prevalence of TMD (mild, moderate, and severe) was 89.2% (n=58) in participants with low back pain and spinal postural abnormalities. There is evidence to suggest that temporomandibular disorder (TMD) can cause musculoskeletal alterations in the body, leading to changes in stress distribution and potentially leading to compensatory mechanisms to reduce pain and discomfort in other areas. This is due to the interconnectivity of the musculoskeletal system through various kinetic chains. Several studies have reported that TMD patients exhibit changes in posture and body mechanics, including increased forward head posture, thoracic kyphosis, and lumbar lordosis, which can lead to altered muscle activation and increased stress on the cervical and lumbar spine[23].

In the present study, a higher number (89%) of the participants having LBP with co-presence of spinal postural deformities had mild to severe TMD. This indicates that there may be a relationship between long-term pain localized in the low back region and the presence of musculoskeletal disorders in the jaw. It is important to note that further research is needed to establish a causal relationship and to determine the directionality of any potential association. Back and jaw pain may have a higher prevalence due to the non-specific effects of central pain processing and sensitization, which could contribute to their co-morbidity.[24] Hagberg conducted case–control study on TMD along with ongoing general musculoskeletal complaints and concluded that patients with TMD also have a higher probability of reporting low back pain than people without TMD.[25] According to research, the most common postural changes seen in specific and nonspecific low back pain are lumbar hyperlordosis, forward head posture, and genu valgus. It was also stated that these postural changes could be risk factors for TMD [26].

The majority of participants in the current study exhibited forward head posture (FHP) as a postural deformity. This could be due to the fact that anomalies at the cervical spine, which is the joint connecting the skull and spine, are associated with

temporomandibular joint (TMJ) pain and mobility restrictions. FHP is characterized by slumped or rounded shoulders with a concomitant extension of the upper cervical spine, causing the head to shift anteriorly beyond its normal axis. This alteration in the neuromuscular mechanism influences the entire masticatory system, thus influencing the resting position of the mandible.[27] Additionally, FHP has been shown to have an effect on mandibular movement and dental occlusion[28-29].

In the present study, a higher Fonseca score for TMD was observed in females than in males. This finding is consistent with previous research conducted by John et al, who suggested that widespread pain is a risk factor for the onset of dysfunctional TMD pain in women, but not in men.[4] Poveda et al and Manfredini et al documented a greater frequency and severity of TMD in females than in males.[29] This female predominance can be explained due to hormonal and anatomical differences. TMD is diagnosed more often in women during childbearing years when estrogen and progesterone levels are higher which leads to joint laxity and further inflammation.[30] Further, this can be explained by the anatomical differences in the jaw and skull between genders that alter the forces on the temporomandibular joint (TMJ). The males exhibit longer, wider, and thicker maxillary bones (upper jaw). In males, the mandible - or lower jaw - forms a less obtuse angle between its top and bottom portions compared to females. Additionally, the temporal fossa/socket is deeper, and the mandibular condyle or head is larger. These anatomical differences contribute to a more stable translation environment of the temporomandibular joint (TMJ) in males than in females.[30] Additionally; this can also be related to the higher prevalence of LBP in females than males which is due to a range of factors, such as societal and cultural expectations, as well as biological factors such as hormonal fluctuations.[31] The results of the present study are in accordance with females presenting with severe back pain associated with disability than their counterparts.

Although not statistically significant, the present study showed that the mean of the Fonseca score was higher in the older age group (41-65 years) than in the younger age group (20-40 years). One of the possible reasons for it could be that teeth require more attention as you get older. TMJ issue arises as gums become weakened and teeth fall out. TMD in elderly people is frequently caused by the restoration process of a tooth-like dental crown or any other dental surgery. While Russek hypothesized that the severity of postural abnormalities would be greater in older populations than in younger populations, the present study found no significant difference in spinal postural deformities across age groups.[32] Additionally, Yadav et al found that older adults, particularly women, are more likely to experience TMJ degeneration, with symptoms that are mild and self-limiting and can be managed with self-care.[33] Grlegel-Morris et al suggested that investigating the effects of age on posture is still important, as postural abnormalities observed in younger populations may be more amenable to change[34].

Limitations

This study only assessed spinal postural deformities and did not evaluate other postural deviations such as pelvic tilts, genu varum/valgum, and other postural asymmetries. This may have limited the understanding of the relationship between other postural deviations and TMD. Since the study was cross-sectional in nature, it is difficult to establish a causal relationship between the two conditions and understand whether TMD was the result of postural deformities or vice versa. The limited sample size in this study may not be fully representative of the overall population, potentially impacting the generalizability of the research results.

CONCLUSION

The present study concluded that the occurrence of TMD is highly prevalent in patients with low back pain and spinal postural deformities. TMD showed an association with all spinal postural deformities with a higher percentage seen in FHP. The findings of the study imply that individuals with low back pain and spinal postural deformity should also be evaluated for TMJ dysfunction and initiate early intervention. In the future case-control studies should be conducted so as to compare the occurrence of TMD in individuals with and without LBP and the presence of postural deformities

ACKNOWLEDGMENTS: We would like to thank the health minds firm for extending their help to perform statistical analysis of the data

REFERENCES:

1. Eriksson PO, Ha¨ggman-Henrikson B, Nordh E, Zafar H. Coordinated mandibular and head–neck movements during rhythmic jaw activities in man. J Dent Res. 2000; 79: 1378–84.
2. LeResche L, Saunders K, Von Korff MR, Barlow W, Dworkin SF. Use of exogenous hormones and risk of temporomandibular disorder pain. Pain. 1997 Jan;69(1-2):153-60. doi: 10.1016/s0304-3959(96)03230-7. PMID: 9060026.Gray RJ, Davies SJ, Quayle, AA. A clinical approach to temporomandibular disorders. Br Dent J. 1994; 176: 429-435.

3. John MT, Miglioretti DL, LeResche L, Von Korff M, Critchlow CW. Widespread pain is a risk factor for dysfunctional temporomandibular disorder pain. Pain. 2003; 102: 257–63.
4. Nitzschke E, Hildenbrand M. Epidemiology of kyphosis in school children. Z OrthoplhreGrenzgeb. 1990; 128: 477-81.
5. Wiesinger B, Malker H, Englund E, Wanman A. Back pain in relation to musculoskeletal disorders in the jaw-face: a matched case-control study. Pain. 2007; 131: 311–19.
6. Souchard PE. Reeducação Postural Global. São Paulo: Ícone, 1990.
7. Rocabado M. Cabeza e Cuello – Tratamiento Articular. Buenos Aires: Intermédica, 1979.
8. Falla D, Farina D. Neural and muscular factors associated with motor impairment in neck pain. CurrRheumatol Rep. 2007;9(6):497-502.
9. Armijo-Olivo S, Pitance L, Singh V, Neto F, Thie N, Michelotti A. Effectiveness of manual therapy and stretching for temporomandibular joint disorders: a systematic review. J Oral Rehabil. 2011;38(8): 630-638.
10. Saito ET, Akashi PMH, Sacco ICN. Global body posture evaluation in patients with temporomandibular joint disorder. Clinics. 2009;64(1):35-9.
11. Fernandes G, Franco AL, Siqueira JT, Gonçalves DA, Camparis CM. Forward head posture and neck mobility in temporomandibular disorder patients. J CraniomandibPract. 2012;30(2):123-128.
12. Michelotti A, Farella M, Gallo LM, Veltri A, Palla S, Martina R. Effect of occlusal and behavioral factors on condylar guidance during lateral movements in healthy subjects and patients with temporomandibular disorder. J Orofac Pain. 2004;18(1):26-32.
13. Laird RA, Gilbert J, Kent P, Keating JL. (2014). Comparing lumbo-pelvic kinematics in people with and without back pain: a systematic review and meta-analysis. BMC Musculoskeletal Disorders 15: 1-17.
14. Tok D. (2019). Evaluation of postural deformities and physical therapy in low back pain. Journal of Physical Therapy Science 31(8): 710-715
15. Marques, A. P., Gondim, D. V., Almeida, D. A., Dibai-Filho, A. V., Porporatti, A. L., & Costa, Y. M. (2020). Evaluation of the angle of the forward head posture by the Protractor software application. Cranio, 38(6), 387-392.
16. F. Teixeira and G. Carvalho, "Reliability and validity of thoracic kyphosis measurements using flexicurve method," *RevistaBrasileira de Fisioterapia*, vol. 11, no. 3, pp. 199–204, 2007.
17. Lin RM, Jou IM, Yu CY. Lumbar lordosis: normal adults. J Formos Med Assoc. 1992 Mar;91(3):329-33. PMID: 1354697
18. Lee JH. Effects of forward head posture on static and dynamic balance control. J PhysTher Sci. 2016;28(1):274-277. doi:10.1589/jpts.28.274
19. Fonseca DM, Bonfante G, Valle AL, Freitas SF, et al. (2010). Reliability of physical examination for diagnosis of temporomandibular disorders. Journal of Orofacial Pain 24(4): 409-414.
20. Johansson A, Unell L, Carlsson GE, Söderfeldt B, et al. (2017). Validation of a questionnaire for self-assessment of TMD based on ICD-11 criteria. Journal of Oral Rehabilitation 44(11): 853-858.
21. Fairbank JC, Couper J, Davies JB, O'Brien JP. The Oswestry low back pain disability questionnaire. Physiotherapy. 1980;66(8):271-273.
22. Senna A, Calixtre LB, Silva-Junior FP, Oliveira-Neto OB, et al. (2010). The association of balance deficits and temporal analysis of gait in patients with temporomandibular joint dysfunction. Archives of Physical Medicine and Rehabilitation 91(4): 550-556.
23. Balagué F1, Mannion AF, Pellisé F, Cedraschi C. Non-specific low back pain. Lancet. 2012 Feb 4;379(9814):482-91.
24. Hagberg C. General musculoskeletal complaints in a group of patients with craniomandibular disorders (CMD). A case control study. Swed Dent J. 1991; 15: 179–85.
25. SilvinaCortese, Ana Mondello, Ricardo Galarza, Ana Biondi. Postural alterations as a risk factor for temporomandibular disorders. ActaOdontol. Latinoam, 2017; Vol. 30: 57-61.
26. Sperry, M.M.; Ita, M.E.; Kartha, S.; Zhang, S.; Yu, Y.H.; Winkelstein, B. The Interface of Mechanics and Nociception in Joint Pathophysiology: Insights From the Facet and Temporomandibular Joints. J. Biomech. Eng. 2017, 139.
27. Goldstein DF, Kraus SL, Williams WB, and Glasheen-Wray MB. Influence of Cervical Posture on Mandibular Movement. J. Pros. Dent. 1984. 52:421.
28. McClean LF, Brennan HG, and Friedman MGF. Effects of Changing Body Position on Dental Occlusion. J. Dent. Res. 1973. 52:1041.
29. Poveda-Roda R, Bagan JV, Sanchis-Bielsa JM, Carbonell E. (2007) "Prevalence of temporomandibular disorders in a Spanish population of patients with fibromyalgia." Journal of Oral Rehabilitation, 34(11): 832-838.
30. Athletico. TMD: Differences in women vs. men [Internet]. Athletico Physical Therapy . 2018 [cited 2023Apr18]. Available from: https://www.athletico.com/2018/05/16/tmd-differences-women-vs-men/

31. Wu A, March L, Zheng X, Huang J, Wang X, Zhao J, Blyth FM, Smith E, Buchbinder R, Hoy D. Global low back pain prevalence and years lived with disability from 1990 to 2017: estimates from the Global Burden of Disease Study 2017. Annals of translational medicine. 2020 Mar;8(6).
32. Russek, L. N., Errico, T. J., & Katz, D. E. (1988). Lumbar lordosis in aging women: The “batman” shape. Spine, 13(9), 1073-1080.
33. Yadav S, Yang Y, Dutra EH, Robinson JL, Wadhwa S. Temporomandibular joint disorders in older adults. Journal of the American Geriatrics Society. 2018 Jul; 66(6): 1213-7.
34. Griegel-Morris P, Larson K, Mueller-Klaus K, Oatis CA. Incidence of common postural abnormalities in the cervical, shoulder, and thoracic regions and their association with pain in two age groups of healthy subjects. PhysTher 1992; 72: 425-31.