GŁOGOWSKA, Karen, WOJTAS, Mikołaj, KAPICA, Marcin, MOMOT, Karol, ŻMIJEWSKA, Aleksandra, SZTYBÓR, Mateusz, KRZYŻANOWSKA, Maria, MALESZEWSKA, Monika, PIĄTKIEWICZ, Julia and NOWAK, Gabriela. The association between body posture and malocclusion - a literature review. Journal of Education, Health and Sport. 2024;62:240-252. eISSN 2391-8306.
https://dx.doi.org/10.12775/JEHS.2024.62.015
https://apcz.umk.pl/JEHS/article/view/48440
https://zenodo.org/records/10693822

The journal has had 40 points in Minister of Science and Higher Education of Poland parametric evaluation. Annex to the announcement of the Minister of Education and Science of 05.01.2024 No. 32318. Has a Journal's Unique Identifier: 201159. Scientific disciplines assigned: Physical culture sciences (Field of medical and health sciences); Health Sciences (Field of medical and health sciences).
Punkty Ministerialne 40 punktów. Załącznik do komunikatu Ministra Nauki i Szkolnictwa Wyższego z dnia 05.01.2024 Lp. 32318. Posiada Unikatowy Identyfikator Czasopisma: 201159. Przypisane dyscypliny naukowe: Nauki o kulturze fizycznej (Dziedzina nauk medycznych i nauk o zdrowiu); Nauki o zdrowiu (Dziedzina nauk medycznych i nauk o zdrowiu).
The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 30.01.2024. Revised: 15.02.2024. Accepted: 22.02.2024. Published: 22.02.2024.

The association between body posture and malocclusion - a literature review

1. Karen Głogowska, DMD

The University Dental Center Medical University of Warsaw, Binieckiego 6, 02-097 Warsaw, Poland, https://orcid.org/0009-0004-9869-3374, karen.glogowska@gmail.com

2. Mikołaj Wojtas, MD

Health Care Team of the District Hospital In Sochaczew, Batalionów Chłopskich 3/7, 96-500 Sochaczew, https://orcid.org/0009-0006-1092-3214, wojtas.m12@gmail.com

3. Marcin Kapica, MD

Health Care Team of the District Hospital In Sochaczew, Batalionów Chłopskich 3/7, 96-500 Sochaczew, https://orcid.org/0009-0005-2191-034X, marcin_kapica@icloud.com

4. Karol Momot, MD

Chair and Department of Experimental and Clinical Physiology, Laboratory of Centre for Preclinical Research, Medical University of Warsaw, Banacha 1b, 02-097 Warsaw, Poland
https://orcid.org/0000-0001-8659-2948, karolmomot@icloud.com

5.Aleksandra Żmijewska, MD

Railway Hospital of dr. Włodzimierz Roefler in Pruszków, Warsztatowa 1, 05-800 Pruszków
https://orcid.org/0009-0002-6281-8943, zmijewskaleksandra@gmail.com

6. Mateusz Sztybór, MD

Provincial Polyclinical Hospital in Płock of Marcina Kacprzaka, Medyczna 19, 09–400 Płock
https://orcid.org/0009-0000-7511-3534, mateuszsztybor@onet.pl

7. Maria Krzyżanowska, MD

Military Institute of Medicine - National Research Institute, Szaserów 128, 04-141 Warszawa
https://orcid.org/0009-0002-2148-4414, mariaannakrzyzanowska@gmail.com

8. Monika Maleszewska, MD
Dr Anna Gostynska Wolski Hospital, Independent Public Health Care Institution, Marcina Kasprzaka 17, 01-211 Warsaw, https://orcid.org/0009-0006-4623-7742, monikamaleszewskaa@gmail.com
9. Julia Piątkiewicz, MD
The Infant Jesus Teaching Hospital, Lindleya 4 02-005 Warszawa, https://orcid.org/ 0009-0005-1969-3593, julia.piatkiewicz@onet.pl
10. Gabriela Nowak, MD
County Health Center in Otwock Sp. z o.o, Batorego 44, 05-400 Otwock
https://orcid.org/0009-0000-4942-9914, gabi098098098@gmail.com

Corresponding author: Mikołaj Wojtas, MD, wojtas.m12@gmail.com

Abstract

Effective body posture entails the correct alignment of body parts in relation to each other and is crucial for preserving balance, stability, and the efficient operation of muscles and joints. The major types of posture abnormalities such as lordosis, kyphosis and scoliosis can lead to alterations in various areas of the body, such as stomatognatic system. The potential correlation between malocclusion and body posture remains a subject of controversy. The aim of this review is to investigate and evaluate the association between posture defects and malocclusion on the basis of literature.

This literature review has analyzed 18 studies. Inclusion criteria: clinical researches published after 2010, regarding children and adults. PubMed and Google Scholar has been searched to identify the papers. In 18 analyzed studies, 2133 patients were enrolled (including 979 children aged 4-18). A positive correlation between scoliosis and different types of malocclusion has been proven by six papers. There are also other noteworthy dependencies, such as overjet and pelvic torsion, kyphosis and sagittal position of mandible, skeletal Class III and torticollis, cross bite and scapula plane.

Adolescent Idiopathic Scoliosis significantly affects the stomatognathic system, leading to issues like crossbite, crowding, increased overjet, overbite, partial open bite, and midline deviation. Orthopedists should collaborate with orthodontists for comprehensive treatment, particularly during developmental stages.

Keywords: scoliosis; orthopedics; malocclusion; orthodontics

Introduction and purpose

The intricate relationship between oral and skeletal structures has long captivated the attention of clinicians and researchers alike. Recent scientific inquiry has unveiled a compelling dimension within this paradigm — the potential association between posture deformities and malocclusion [11]. Body posture encompasses the positioning and alignment of the body in space, encompassing the arrangement of body parts like the head, shoulders, spine, and limbs. It defines the overall carriage or demeanor of the body. Effective body posture entails the correct alignment of body parts in relation to each other and is crucial for preserving balance, stability, and the efficient operation of muscles and joints. Several factors, including habits, lifestyle, muscle strength, and the ergonomic features of the environment, can influence an individual's body posture. Maintaining proper and well-balanced body posture is vital for averting musculoskeletal issues, diminishing the likelihood of injuries, and fostering overall physical health [25]. In contrast, inadequate body posture, such as slouching or hunching over, can result in muscle and joint strain, leading to discomfort and potential long-term complications [26]. Conversely, sound body posture supports optimal biomechanics, diminishes injury risks, and contributes to an overall sense of well-being. Postural deformities, also referred to as postural abnormalities or malalignments, can impact various areas of the body. Some significant postural deformities include: kyphosis: characterized by an excessive outward curvature of the spine, kyphosis results in a rounded upper back or a "hunchback" appearance; lordosis: involving an excessive inward curvature of the spine, typically in the lower back, lordosis can lead to a swayback appearance; scoliosis: identified by a lateral (sideways) curvature of the spine, scoliosis manifests as the spine curving either to the left or right. In severe cases, it may impact the alignment of the ribcage [24].

Malocclusion, a term used in dentistry, refers to the misalignment or improper positioning of teeth when the jaws are closed. This misalignment can impact how the upper and lower teeth come together, leading to bite-related issues. Various types of malocclusion exist, each characterized by specific misalignment patterns: overbite: excessive vertical overlap of the upper front teeth over the lower front teeth; underbite: horizontal misalignment where the lower front teeth protrude beyond the upper front teeth; crossbite: lateral misalignment where some upper teeth sit inside the lower teeth; open bite: presence of a gap between upper and lower front or side teeth when the back teeth are together; crowding: insufficient jaw space causing teeth to overlap or twist; rotation: teeth that have turned or twisted out of their normal position. Malocclusion can arise from diverse factors, including genetics, premature loss of primary teeth, improper jaw development, or habits like thumb-sucking. It can impact not just the aesthetic appearance of teeth but also the functionality of the jaw, potentially leading to difficulties in chewing, speech impediments, and discomfort.

Orthodontic interventions, commonly utilizing braces or corrective appliances, are frequently employed to address malocclusion and enhance the alignment of teeth and jaws. In severe cases, surgery may be recommended. The goal of treatment is to improve both the aesthetic and functional aspects of the bite [27].

Both posture and occlusion are integral components of human anatomy, influencing not only functional aspects such as mastication and speech but also contributing significantly to overall well- being. While existing literature has explored each of these domains independently, a comprehensive understanding of their interdependence remains a subject of controversy.

This literature review seeks to delve into the intriguing prospect of a connection between posture deformities and malocclusion, recognizing the nuanced interplay between the craniofacial and postural systems on the basis of literature. As individuals are increasingly being evaluated holistically, beyond traditional disciplinary boundaries, the significance of elucidating potential links between these seemingly disparate aspects becomes paramount. This study aims to bridge the existing gaps in knowledge by rigorously examining published papers and fostering collaborative efforts between orthodontists, orthopedists, and related specialists.

This literature review has analyzed 18 studies. Inclusion criteria: clinical researches published after 2010, regarding children and adults. PubMed and Google Scholar has been searched to identify the papers. In 18 analyzed studies, 2133 patients were enrolled (including 979 children aged 4-18).

Description of the state of knowledge

Overjet and pelvic torsion

Regarding back posture and early orthodontic treatment in children, reducing overjet in the initial stages of orthodontic treatment could be linked to a noticeable impact on pelvic torsion. Pelvic torsion refers to a condition in which the pelvis rotates or twists, causing an asymmetry in the alignment of the pelvic bones [6]. This torsional deviation can contribute to postural imbalances and may result from factors such as muscle imbalances, leg length discrepancies, or structural issues within the pelvic region. Overjet refers to the horizontal gap or protrusion of the upper front teeth beyond the lower front teeth when the jaw is closed [12].

It has been observed that the reduction of the overjet (- 3.9 mm ± 2.1 mm) in Angle Class II

patients with overjet > 9mm results in the improvement in pelvic torsion (- 1.28° ± 0,44°) [1]. Class II malocclusion, also known as retrognathism or overbite, is a dental misalignment where the upper jaw and teeth significantly overlap the lower jaw and teeth, resulting in a protruded appearance [14].

Crossbite and scapula plane

There was also a notable correlation observed between the inclination of the scapula plane and the inequalities in scapula prominence in cases of unilateral functional crossbite [5]. Scapula plane inclination refers to the orientation of the shoulder blades in relation to the frontal plane of the body, while scapula prominence inequalities involve differences in the prominence or position of the shoulder blades. This may be associated with muscular imbalances, postural issues, or conditions affecting the scapulae, potentially impacting shoulder and upper back function. Crossbite occurs when some of the upper teeth sit inside the lower teeth instead of outside, causing a misalignment of the dental arches. There were no identified associations between the side of the crossbite and the side of prominence in back parameters [5].

Scoliosis and Its impact on all types of malocclusion

Scoliosis is a spinal deformity characterized by a lateral (side-to-side) curvature of the spine, forming an "S" or "C" shape. The most frequently encountered types comprised right main thoracic (R-MT) and thoracolumbar or left lumbar scoliosis [13]. This condition can affect any part of the spine but is most commonly seen in the thoracic or lumbar regions. Scoliosis may develop during growth spurts in adolescence (adolescent idiopathic scoliosis) or result from congenital factors, neuromuscular conditions, or other underlying causes. The severity of scoliosis can vary, and treatment options include observation, bracing, and, in some cases, surgical intervention to correct the curvature [19]. The prevalence of malocclusions is higher among children diagnosed with idiopathic scoliosis compared to their counterparts who are in good health [13]. The findings indicated a higher prevalence of crossbite as scoliosis severity increased. Additionally, a statistically significant association was observed between left crossbite and the contralateral side of spinal curve deviation in individuals with scoliosis [7].

In a different study, all individuals with Adolescent Idiopathic Scoliosis (AIS) exhibited at least one abnormal orthodontic trait, whereas 16.7% of the control group had a dentition free from any orthodontic anomaly. In the sagittal dimension, AIS patients displayed a higher prevalence of bilateral distocclusion and unilateral mesiocclusion compared to the control group. Additionally, they more frequently presented with crowding, increased overjet, and overbite than their healthy peers of the same age [13]. Overbite is the vertical overlap of the

upper front teeth over the lower front teeth when the jaws are closed. It measures the extent to which the upper teeth cover the lower teeth vertically.

Concerning the association between the site, side, or severity of scoliosis and the occurrence of malocclusion, asymmetric molar occlusion was more commonly observed in patients with a right convex curve, while unilateral mesiocclusion appeared more frequently in patients with the thoracic apex of the curve [12]. Another study proved that connection was established between an anterior partial open bite and the left proximal thoracic (L-PT) curve. Additionally, a correlation was found between lateral partial crossbite and thoracic dextroscoliosis in the main thoracic region. Furthermore, the severity of scoliosis was observed to be linked to malocclusion, specifically in cases of L-PT with anterior partial open bite and R-MT with scissors bite [13]. A questionnaire study highlights the importance of evaluating the spinal condition in individuals diagnosed with malocclusion and underscores the need to examine specific types of malocclusions in patients who may have or have confirmed cases of scoliosis [11].

The increased Cobb angle and Angle Class II

The Cobb angle serves as a metric in orthopedics for gauging the extent of spinal curvature, particularly in conditions like scoliosis. Precisely, it is the angle created by the lines drawn along the upper endplate of the most inclined vertebra in the curved portion of the spine and the lower endplate of the vertebra directly beneath it. This angle is pivotal in evaluating the severity of spinal deformities, and it plays a significant role in deciding the necessity for treatment and monitoring the advancement of conditions such as scoliosis [21]. Compared to patients exhibiting idiopathic scoliosis (IS), those with congenital scoliosis (CS) demonstrated a higher prevalence of a Cobb angle $\geq 45°$ and included a greater proportion of individuals undergoing surgical interventions. The distribution of the Angle Class II subgroup was notably elevated in both the IS and CS groups when compared to the control group. In contrast to the healthy controls, both CS and IS groups exhibited significantly higher frequencies of asymmetric molar and canine relationships, deviations in upper and lower midlines, anterior deep overbite, unilateral posterior crossbite, and a canted occlusal plane. These frequencies were particularly pronounced in CS patients and, to a lesser extent, in IS patients [14]. Midline deviation refers to the misalignment of the center of the upper and lower dental arches. An upper midline deviation occurs when the center of the upper front teeth does not align with the center of the face, and a lower midline deviation occurs when the center of the lower front teeth does not align with the upper front teeth [22].

Midline deviation and scoliosis

In evaluations conducted in the transverse dimension, the occurrence of lower midline deviation was 39.7% in the IS group and 45.8% in the CS group, both surpassing the

corresponding value in the control group. Conversely, a notable distinction in the ratio of upper midline deviations was observed solely between the CS and control groups. The prevalence of upper midline deviations in the IS group was 25.9%, contrasting with 17.1% in the control group [14].

Left-right dentoalveolar fluctuating, specifically midline deviation and canine deviation, were statistically higher in subjects with idiopathic scoliosis (IS) compared to healthy controls. The magnitude of dentoalveolar asymmetries was not significantly influenced by the direction of the curve, the location of the apical vertebra, or apical translation [15].

Rapid palatal expansion and scoliosis

Understanding how rapid palatal expansion (RPE) influences the spine during development is crucial in clinical settings. RPE is a fixed and expansive therapy that applies substantial forces to gradually separate the midpalatal suture at a daily rate ranging from 0.2 to 0.5 mm [16].

The study involved eighteen patients under orthopedic supervision for juvenile/adolescent idiopathic scoliosis, who were independently undergoing rapid palatal expansion (RPE) for orthodontic purposes. The participants were divided into two groups: Group A comprised 10 subjects with the first spinal radiograph taken before the application of RPE and the second during orthodontic therapy with RPE. Group B consisted of 8 patients with the first radiograph taken during the use of RPE and the second after its removal. Both patient groups exhibited a highly significant difference between the conditions with and without the RPE appliance. In Group A, there was a significant deterioration of the Cobb angle after the application of RPE, while in Group B, a significant improvement in the Cobb angle was observed after the removal of the RPE appliance [16].

The uniqueness of this study stems from the utilization of spinal radiographs, orthopedic diagnosis, and the assessment of scoliosis both before and after the application of the RPE appliance. This comprehensive approach goes beyond the scope of orthodontics alone, as orthodontists, despite their expertise, cannot diagnose or treat patients from an orthopedic standpoint. Conversely, orthopedists lack familiarity with the mechanical actions of orthodontic appliances, which are overseen by specialists in this niche. The collection of these cases resulted from a close collaboration between orthodontists and orthopedists, highlighting the concerted effort to unravel the intricate relationships between the cranial and postural systems [16].

Angle Class III and posture defects such as Torticollis

Moreover, skeletal Class III may also contribute to postural deformities. Class III malocclusion, also known as prognathism or underbite, is a dental misalignment where the lower jaw and teeth protrude forward, causing the lower teeth to be in front of the upper teeth when the jaws are closed. Photogrammetric postural assessment revealed that the majority of anatomical structures in patients with skeletal Class III dentofacial deformities deviated from the normal range prior to orthognathic surgery.

These findings imply that dentofacial abnormalities may contribute to postural disorders in this particular population [8]. Other study reveals a robust correlation between asymmetrical Class III malocclusion, torticollis, and cranial base asymmetry. Torticollis is a condition characterized by the involuntary contraction or shortening of neck muscles, causing the head to tilt or rotate to one side. This condition can be congenital or acquired and may result in restricted neck movement and discomfort [23]. The findings suggest that undiagnosed torticollis is a probable cause for what would otherwise be considered idiopathic cranial base asymmetry. Furthermore, cranial base asymmetry is identified as a factor contributing to facial asymmetry and malocclusion. [18].

Kyphosis and SNB angle

Kyphosis is a spinal condition characterized by an abnormal, excessive outward curvature of the spine, leading to a rounded or hunched back appearance. This curvature is most commonly observed in the thoracic (mid-back) region. While a certain degree of kyphosis is normal, particularly in the upper back, an exaggerated or pathological form can result from factors such as poor posture, osteoporosis, developmental issues, or specific medical conditions [20]. There is a

noteworthy correlation between the sagittal position of the mandible (SNB angle) and a kyphotic posture. Kyphotic posture and a diminished SNB angle were found to be more prevalent in males.

[9].

Infraocclusion and cervical curvature

Examining the postural defects in patients with infraocclusion, there was only a mild positive correlation observed between the cervical curvature and the vertical dimension of occlusion. More than 90% of patients exhibiting infraocclusion had their cervical curvature categorized as either straight or kyphosis. In contrast, 36% of control subjects had their cervical curvature classified as lordosis [10]. Lordosis refers to an abnormal, exaggerated inward curvature of the spine, creating a concave shape. This curvature is typically observed in the lumbar or cervical regions of the spine. Lordosis is a natural and essential component of

the spine's structure, contributing to flexibility and shock absorption. However, excessive lordosis can occur due to factors such as poor posture, muscle imbalances, obesity, or specific medical conditions [24].

Twin-block and body posture

The primary goals of employing the Twin-block appliance in treatment include rectifying Class II malocclusion, as well as minimizing overjet and overbite. Addressing distal occlusion with functional appliances not only contributes to enhancements in lip competency and orofacial function through muscle adaptation but also brings about dental and skeletal alterations. Consequently, modifications in the jaw relationship may induce adaptations in body posture. However, the study that examined the impact of orthodontic treatment using the Twin-block appliance on body posture in children, revealed that the alterations in body posture observed during the Twin-block appliance treatment were indicative of natural physiological growth rather than a reaction to enhanced occlusion [3].

Clear aligners' impact on the spine

As far as clear aligners are concerned, the coverage of occlusion by aligners may impact body posture, affecting not only the upper spine but also the lower spine.These transparent, removable trays gradually shift teeth into their desired positions. Clear aligners are an alternative to traditional braces and offer a more discreet and convenient option for orthodontic treatment. After a span of 6 months of undergoing clear aligner treatment, connections were identified between the Kyphosis Angle, Upper Thoracic Inclination, Pelvic Inclination, and body posture [4].

Doubts

However, a scientific paper comparing occlusal conditions in adults with their body posture did not reveal any variations in trunk asymmetry concerning the sagittal jaw relationship. Moreover, there was no significant correlation found between back posture and sagittal jaw position among patients classified as Class II and Class III [2]. Other randomized clinical trial involving a juvenile population with unilateral posterior crossbite claims, that the chosen early orthodontic treatment protocol is shown not to have adverse effects on postural parameters. No clinically significant differences in parameters such as kyphotic and lordotic angles, surface rotation, lateral deviation, pelvic tilt, and pelvic torsion were observed between the control and therapy groups [6]. Another study explored potential connections between idiopathic scoliosis patients, categorized by Cobb

angle and curve type and their facial features analyzed in horizontal, vertical, and anteroposterior planes using cephalometric measurements. Contrary to the null hypothesis, the occurrence of deviations in facial forms did not increase proportionally with the severity of scoliosis. The study's findings indicate that there is no evident relationship between the severity of scoliosis and variations in facial form among individuals with idiopathic scoliosis [17].

Conclusions

The observed higher prevalence of malocclusions among children diagnosed with idiopathic scoliosis underscores the intricate interplay between orthodontic and musculoskeletal health. This finding not only emphasizes the need for comprehensive health assessments but also suggests potential links between these two conditions. As we delve deeper into understanding these connections, further research becomes imperative to inform holistic approaches to healthcare, considering both dental and spinal aspects for a more integrated and effective treatment strategy.

This insight into the correlation between idiopathic scoliosis and malocclusions serves as a valuable foundation for future investigations and underscores the importance of interdisciplinary collaboration in addressing the multifaceted nature of health issues in pediatric populations.

Disclosures

Author's contribution:

Conceptualization: Karen Głogowska, Mikołaj Wojtas; Methodology: Karol Momot, Marcin Kapica; Formal analysis: Aleksandra Żmijewska, Mateusz Sztybór; Investigation: Maria Krzyżanowska, Monika Maleszewska; Writing - rough preparation: Julia Piątkiewicz, Gabriela Nowak; Writing - review and editing: Karen Głogowska, Mikołaj Wojtas; Supervision: Mikołaj Wojtas, Karen Głogowska. All authors have read and agreed with the published version of the manuscript.

Funding Statement: This Research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interests: The authors declare no conflict of interest.

References

1. Klostermann I, Kirschneck C, LippoldC, Chhatwani S. Relationship between back posture and early orthodontic treatment in children. Head Face Med. 2021 Feb 5;17(1):4. doi: 10.1186/s13005-021-00255-5. PMID: 33546715; PMCID: PMC7863507.
2. Sofyanti E, Boel T, Sihombing ARN. The correlation between back posture and sagittal jaw position in adult orthodontic patients. J Taibah Univ Med Sci. 2020 Nov 10;16(1):63-69. doi: 10.1016/j.jtumed.2020.10.009. PMID: 33603633; PMCID: PMC7858012.
3. Smailiene D, IntieneA, Dobradziejute I, Ku$leika G. Effect of Treatment with Twin-Block Appliances on Body Posture in Class II Malocclusion Subjects: A Prospective Clinical Study. Med Sci Monit. 2017 Jan 20;23:343-352. doi: 10.12659/msm.899088. PMID: 28107314; PMCID: PMC5279871.
4. Parrini S, Comba B, Rossini G, Ravera S, Cugliari G, De Giorgi I, Deregibus A, Castroflorio T. Postural changes in orthodontic patients treated with clear aligners: A rasterstereographic study. J Electromyogr Kinesiol. 2018 Feb;38:44-48. doi: 10.1016/j.jelekin.2017.11.002. Epub 2017 Nov 14. PMID: 29156321.
5. Primozic J, Perinetti G, ZhurovA, Richmond S, Ovsenik M, Antolic V, Primozic J. Three-dimensional assessment of back symmetry in subjects with unilateral functional crossbite during the pre-pubertal growth phase: a controlled study. Eur J Orthod. 2019 May 24;41(3):250-257. doi: 10.1093/ejo/cjy053. PMID: 30102316.
6. LippoldC, Moiseenko T, Drerup B, Schilgen M, Végh A, Danesh G. Spine deviations and orthodontic treatment of asymmetric malocclusions in children. BMC Musculoskelet Disord. 2012 Aug 21;13:151. doi: 10.1186/1471-2474-13-151. PMID: 22906114; PMCID: PMC3489858.
7. Sambataro S, Bocchieri S, Cervino G, La Bruna R, Cicciù A, Innorta M, Torrisi B, Cicciù M. Correlations between Malocclusion and Postural Anomalies in Children with Mixed Dentition. J Funct Morphol Kinesiol. 2019 Jul 19;4(3):45. doi: 10.3390/jfmk4030045. PMID: 33467360; PMCID: PMC7739254.
8. Kulczynski FZ, Andriola FO, Deon PH, Melo DADS, Pagnoncelli RM. Postural Assessment in Class III Patients Before Orthognathic Surgery. J Oral Maxillofac Surg. 2018 Feb;76(2):426-435. doi: 10.1016/j.joms.2017.07.157. Epub 2017 Jul 25. PMID: 28822721.
9. sidlauskiene M, Smailiene D, Lopatiene K, 竣ekanauskas E, Pribui$iene R, sidlauskas M. Relationships between Malocclusion, Body Posture, and Nasopharyngeal Pathology in Pre-Orthodontic Children. Med Sci Monit. 2015 Jun 18;21:1765-73. doi: 10.12659/MSM.893395. PMID: 26086193; PMCID: PMC4484615.

10.Ando E, Shigeta Y, HirabayashiR, Ikawa T, Hirai S, Katsumura S, Ogawa T. Cervical curvature variations in patients with infraocclusion. J Oral Rehabil. 2014 Aug;41(8):601-7. doi: 10.1111/ joor.12187. Epub 2014 May 21. PMID: 24849697.

11. Saccomanno S, Saran S, Paskay LC, Giannotta N, Mastrapasqua RF, Pirino A, Scoppa F. Malocclusion and Scoliosis: Is There a Correlation? J Pers Med. 2023 Aug 10;13(8):1249. doi: 10.3390/jpm13081249. PMID: 37623498; PMCID: PMC10455086.

12.Gtowacka J, Opydo-Szymaczek J, Mehr K, Pawlaczyk-Kamiehska T, Gtowacki J. Adolescent idiopathic scoliosis and malocclusion - a cross sectional study of female patients without previous orthodontic treatment. AnthropolAnz. 2020 Nov 30;77(4):269-280. doi: 10.1127/ anthranz/2020/1198. PMID: 32706018.

13.Laskowska M, Olczak-Kowalczyk D, Zadurska M, Czubak J, Czubak-Wrzosek M, Walerzak M, Tyrakowski M. Evaluation of a relationship between malocclusion and idiopathic scoliosis in children and adolescents. J Child Orthop. 2019 Dec 1;13(6):600-606. doi: 10.1302/1863-2548.13.190100. PMID: 31908677; PMCID: PMC6924124.

14.Zhang H, Ma J, Zhang Z, Feng Y, Cai C, Wang C. Occlusal deviations in adolescents with idiopathic and congenital scoliosis. Korean J Orthod. 2022 May 25;52(3):165-171. doi: 10.4041/kjod21.259. PMID: 35535016; PMCID: PMC9117788.

15.Lewandowska J, Opydo-Szymaczek J, Mehr K, Głowacki J. Bilateral dentoalveolar asymmetries in female patients with adolescent idiopathic scoliosis. Acta Bioeng Biomech. 2019;21(4):53-62. PMID: 32022798.

16.Piancino MG, MacDonald F, Laponte I, Cannavale R, Crincoli V, Dalmasso P. Juvenile/ Adolescent Idiopatic Scoliosis and Rapid Palatal Expansion. A Pilot Study. Children (Basel). 2021 Apr 30;8(5):362. doi: 10.3390/children8050362. PMID: 33946317; PMCID: PMC8146753.

17.Kim TH, Kim JH, Kim YJ, Cho IS, Lim YK, Lee DY. The relation between idiopathic scoliosis and the frontal and lateral facial form. Korean J Orthod. 2014 Sep;44(5):254-62. doi: 10.4041/ kjod.2014.44.5.254. Epub 2014 Sep 25. PMID: 25309865; PMCID: PMC4192527.

18.Yuan JT, Teng E, Heller JB, Kawamoto HK, Bradley JP. Asymmetric class III malocclusion: association with cranial base deformation and occult torticollis. J Craniofac Surg. 2012 Sep;23(5):1421-4. doi: 10.1097/SCS.0b013e31825b3bc7. PMID: 22948635.

19.Shakil H, Iqbal ZA, Al-Ghadir AH. Scoliosis: review of types of curves, etiological theories and conservative treatment. J Back Musculoskelet Rehabil. 2014;27(2):111-5. doi: 10.3233/ BMR-130438. PMID: 24284269.

20.Yaman O, Dalbayrak S. Kyphosis and review of the literature. Turk Neurosurg. 2014;24(4):455-65. doi: 10.5137/1019-5149.JTN.8940-13.0. PMID: 25050667.

21.Jin C, Wang S, Yang G, Li E, Liang Z. A Review of the Methods on Cobb Angle Measurements for Spinal Curvature. Sensors (Basel). 2022 Apr 24;22(9):3258. doi: 10.3390/s22093258.
PMID: 35590951; PMCID: PMC9101880.

22.Cardash HS, Ormanier Z, Laufer BZ. Observable deviation of the facial and anterior tooth midlines. J Prosthet Dent. 2003 Mar;89(3):282-5. doi: 10.1067/mpr.2003.68. PMID: 12644804.

23.Tomczak KK, Rosman NP. Torticollis. J Child Neurol. 2013 Mar;28(3):365-78. doi: 10.1177/0883073812469294. Epub 2012 Dec 26. PMID: 23271760.

24.Abelin-Genevois K. Sagittal balance of the spine. Orthop Traumatol Surg Res. 2021 Feb;107(1S):102769. doi: 10.1016/j.otsr.2020.102769. Epub 2020 Dec 13. PMID: 33321235.

25.Szczygieł E, Blaut J, Zielonka-Pycka K, Tomaszewski K, Golec J, Czechowska D, Masłoń A, Golec E. The Impact of Deep Muscle Training on the Quality of Posture and Breathing. J Mot Behav. 2018 Mar-Apr;50(2):219-227. doi: 10.1080/00222895.2017.1327413. Epub 2017 Aug 18. PMID: 28820662.

26.Szczygieł E, Zielonka K, Mętel S, Golec J. Musculo-skeletal and pulmonary effects of sitting position - a systematic review. Ann Agric Environ Med. 2017 Mar 31;24(1):8-12. doi: 10.5604/12321966.1227647. PMID: 28378964.

27.Masucci C, Oueiss A, Maniere-Ezvan A, Orthlieb JD, Casazza E. Qu'est-ce qu'une malocclusion ? [What is a malocclusion?]. Orthod Fr. 2020 Jun 1;91(1-2):57-67. French. doi: 10.1684/orthodfr.2020.11. PMID: 33146134.