Stomatognathic system and the impact of the tongue on postural development during childhood: a systematic review

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Abstract

The relationship between tongue function, dental occlusion, and posture is gaining increasing attention, particularly during the developmental years, a critical period for neuromuscular and skeletal maturation. A multidisciplinary care model integrating orthodontics, physiotherapy, and posturology may optimize therapeutic outcomes and preventive strategies during these pivotal phases of pediatric growth. Future research should prioritize longitudinal study designs and standardized outcome measures to clarify causal relationships better and guide clinical protocols.

***Objective*: To examine the available scientific evidence regarding the association between tongue function, occlusion, and posture in children, identifying correlations with spinal alignment, cervical posture, and head position.**

***Methods*: A systematic review was conducted, encompassing observational studies, clinical trials, and systematic reviews published up to 2025. Studies evaluating the association between alterations in occlusal or tongue function and postural modifications in pediatric populations were included. The review is registered in the PROSPERO database (Registration Number: [ID 1115660]).**

***Results*: Thirty studies met the inclusion criteria. The findings indicate consistent associations between malocclusions (e.g., Class II, Class III, crossbite), tongue-related dysfunctions (e.g., short lingual frenulum, low resting tongue posture), and postural deviations such as spinal misalignments, forward head posture, scapular asymmetry, and pelvic tilt. Nonetheless, heterogeneity in study design, assessment methods, and sample characteristics constrains the robustness and generalizability of these correlations.**

***Conclusions*: Tongue function and dental occlusion may influence postural development in children, particularly in the cervical and craniofacial regions. While current evidence points to clinically relevant patterns, further high-quality research is needed to clarify causality and quantify effect sizes. A multidisciplinary approach, integrating orthodontics, physiotherapy, and posturology, is recommended not only for therapeutic management but also as a preventive strategy during critical stages of growth.**

Keywords: Childhood, Posture, Tongue, Stomatognathic, Lingual dysfunction, Tongue function, Children, Pediatric, Infant, Oral development, Ankyloglossia, Malocclusion.

Introduction

Numerous studies have explored the complex relationship between dental occlusion,

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tongue function, and body posture (2, 3, 7, 10, 20, 33). In pediatric populations, these factors are even more critical as they interact during key neuromuscular and skeletal development phases. The tongue is a central functional element within the stomatognathic system (26), contributing to swallowing, phonation, and oro-cervico-cephalic balance.

The facial mass plays a crucial role in craniofacial growth and dental occlusion. Although not classified as a primary postural receptor (6), the stomatognathic system may exert biomechanical influence on postural regulation but can act as a postural interference, potentially affecting overall body posture.

The influence of the tongue on global postural imbalance remains a subject of debate and lacks universal recognition. Nevertheless, its significance is more widely acknowledged in the cervical region, owing to its critical functions such as breathing and swallowing. Additionally, the connection between the tongue and the anterior chain of the myofascial meridians indicates a possible impact on posture, particularly in instances of a short lingual frenulum (6) (27). As early as the 1990s, Ait-Abbas et al. emphasized the relationship between occlusion and posture during childhood development (1).

The theoretical framework proposing that alterations in tongue position or function may impact overall body posture is grounded in the understanding of myofascial chains, anatomical connections, and clinical observations of compensatory adaptations. Imaging studies, such as that conducted by Decocq et al. (10), have demonstrated that changes in cephalometric parameters following orthodontic intervention may be associated with modifications in static posture (10). Various researchers, including Lippold et al. (17, 18) and Tecco et al. (36), have examined the relationship between occlusion and spinal alignment, identifying correlations between malocclusions and postural variations in the spine, pelvis, or head. Although this systematic review is centered on the pediatric population (0–18 years), selected studies involving adults provide valuable methodological insights. Ohlendorf, D. M., et al., have yet to establish the feasibility of objective postural assessment utilizing 3D scanning in conjunction with mandibular analysis (29). In addition, Decocq et al. emphasized the influence of occlusion on postural alignment, thereby supporting the notion of the stomatognathic system as a postural receptor (10). While these findings are not directly applicable to children, they offer theoretical and methodological support for future investigations into these relationships within pediatric populations.

Surgical interventions such as frenotomy and orthognathic correction for Class III malocclusion have a structural impact on craniofacial and cervical posture. Conversely, postural therapies operate through neuromuscular adaptation. Although outcomes of surgical procedures in adults are documented, the efficacy of pediatric postural correction remains insufficiently explored, thereby emphasizing a gap in early functional intervention.

In pediatric dentistry and orthodontics, posture assessment often precedes the analysis of occlusion and dental development. Understanding the global postural framework helps contextualize how the stomatognathic system might interact with or influence overall body balance. Postural assessment is an integral part of pediatric dentistry (23).

Although these relationships are of significant interest to orthodontists, physiotherapists, and speech therapists, the literature remains heterogeneous, with varying methodologies and study designs that complicate clinical generalization.

This review seeks to collect and synthesize the existing evidence concerning the association between tongue function, occlusion, and posture within pediatric populations. It emphasizes correlations with spinal alignment, cervical posture, and head orientation. The purpose is to offer a comprehensive overview to support multidisciplinary clinical practice and to guide future research efforts.

Materials and methods

Search Strategy

A systematic literature search was conducted in accordance with the PRISMA guidelines across the following databases: PubMed, CINAHL, Scopus, and Web of Science, with no restriction on date up to June 2025. The search strategy integrated keywords and MeSH terms concerning tongue function, the stomatognathic system, and posture within the pediatric population.

Search string:

1. “tongue posture” OR “tongue function” OR “lingual dysfunction” OR “tongue thrust” OR “ankyloglossia”) AND

Table 1. PICOS Framework

Element	Definition
P (Population)	Children and adolescents (0-18 years), with or without malocclusions or tongue dysfunctions
I (Intervention/Exposure)	Presence of occlusal alterations (Class I/II/III, crossbite, open bite), short lingual frenulum, tongue posture
C (Comparison)	Subjects with normal occlusion, correct tongue posture, and no stomatognathic dysfunctions
O (Outcomes)	Postural alterations (spinal alignment, cervical posture, scapular position, pelvic tilt, head orientation), changes in postural balance or cephalometric parameters
S (Study design)	Systematic review, including observational studies, cross-sectional, longitudinal studies, RCTs, case series, and systematic reviews

2. "posture" OR "body posture" OR "cervical spine" OR "head posture" AND
3. "children" OR "pediatric" OR "infant" OR "adolescent")

The search was limited to human studies, subjects aged 0–18, and articles published without language limitations.

Inclusion Criteria

- Studies involving children and adolescents (0–18 years).
- Research examining the relationship between tongue position and function, the stomatognathic system, and postural parameters such as head orientation, cervical spine alignment, and overall posture.
- Study designs include randomized controlled trials (RCT), observational studies such as cross-sectional, cohort, and case-control studies, as well as clinical studies and relevant systematic reviews.
- Studies encompassing postural assessment techniques, such as clinical, radiographic, baropodometric, or photographic methods.
- Studies with explicitly documented outcomes concerning body posture, cervical alignment, or musculoskeletal orientation.

Exclusion Criteria

- Research concerning adult populations.
- Case reports, editorials, commentaries, and conference abstracts without full texts.
- Studies are not reporting postural outcomes or investigating the tongue/stomatognathic system.
- Surgery-based studies
- Articles are not accessible in full-text format.

Study Selection Process

Two independent reviewers conducted screening of titles and abstracts to determine eligibility. Full texts of potentially pertinent articles were evaluated according to specified inclusion and exclusion criteria. Any disagreements were addressed through discussion or, if necessary, by consulting a third reviewer. Additionally, reference lists from included articles were manually examined to identify further relevant studies. Several studies deemed potentially relevant were excluded at the full-text review stage because the study populations did not align with the predefined age criteria. These exclusions primarily resulted from the inclusion of participants aged 18 years or older, which fell outside the scope of this pediatric-focused review.

A PRISMA flow diagram was constructed to summarize the selection process.

Data Extraction

For each included study, the following information was extracted:

- First author, year of publication
- Study design
- Sample Size and Age Range
- Evaluation methods of tongue and stomatognathic parameters.
- Methods of Postural Assessment
- Main findings and correlations
- Certain studies, including those involving adult populations or surgical interventions lacking preoperative postural assessment, did not meet the predetermined inclusion criteria and are cited within the text for methodological comparison. Their inclusion highlights existing gaps within pediatric research and underscores the importance of postural and stomatognathic interactions across different age groups. These studies were not incorporated into the systematic review and did not impact the formal synthesis (Fig. 1).

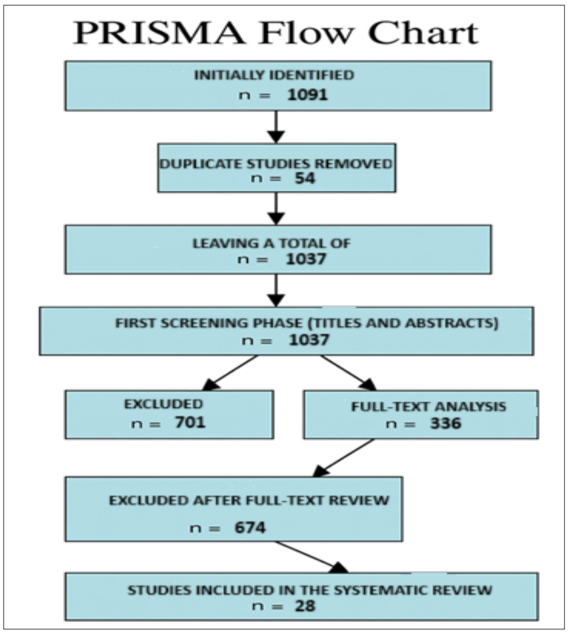

Figure 1. PRISMA Flow Diagram for Systematic Reviews

Quality Assessment: The AXIS tool evaluates the risk of Bias (RoB) in observational studies. The STROBE statement is employed for quality assessment in observational research. The Jadad scale is utilized for randomized controlled trials (RCTs). The ROB 2 tool is applied for RCT assessments. The ROBIS tool is used to evaluate systematic reviews. The AMSTAR 2 instrument assesses the quality of included systematic reviews.

Data Synthesis: Statistical synthesis and summary tables presented.

Study Selection: The initial search yielded 1,091 potentially relevant records. Following the removal of 54 duplicates, 1,037 unique records remained for screening. In the first screening phase, based on titles and abstracts, 701 records were excluded as they did not meet the inclusion criteria. The remaining 336 articles underwent full-text assessment for eligibility. After detailed evaluation, 309 articles were excluded for reasons such as inadequate methodological quality, irrelevant outcomes, or failure to meet predefined criteria. Consequently, 30 studies were included in the final systematic review

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Table 2. Synthesis of the studies.

Author and year	Age	Number of patients	Study design	Aim of the Study	Results
Morales-Atarama P et al. 2025	10-14 years	37	Cross-sectional study	The association between body posture and malocclusion in adolescents	No association found between Angle's malocclusion and body posture (p = 0.277).
Di Palma G. et al. 2025	0–18 years*	Not applicable (review)	Systematic Review	To evaluate the relationship between sagittal skeletal malocclusions and cervical posture in pediatric populations. *Only results pertaining to subjects aged 0–18 years were considered.	The review highlights consistent associations between Class II malocclusion and extended cervical posture. Methodological limitations prevented meta-analysis, but narrative synthesis supports biomechanical plausibility.
Bardellini E. et al. 2022	9-12 years	Not reported	Prospective longitudinal interventional study	Can the Treatment of Dental Malocclusions Affect the Posture in Children	Significant correction of the position of the head, with a physiological extension of C0-C1, a significant improvement of the typology of podalic support and a homogeneous distribution of the body weight on the feet were observed after the treatment of the malocclusions. Conclusion; From our results, the treatment of dental malocclusion can contribute to ameliorate the postural attitude in children.
Brożek-Mądry E et al., 2021	3–17 years	135	Observational cross-sectional study	To assess the impact of a short lingual frenulum on the risk of obstructive sleep apnea syndrome (OSAS) and its association with head-forward posture in children.	Children with a short lingual frenulum showed significantly increased forward head posture and higher prevalence of high-arched palate, indicating a link between ankyloglossia and postural adaptations related to airway function.
Klostermann I. et al 2021	8.2 years	55	Retrospective observational study	Relationship between back posture and early orthodontic treatment in children	Overjet reduction during early orthodontic treatment may be associated with a detectable effect on pelvic torsion
Liu Y. et al. 2018	10-14 years old	94	Cross-sectional observational study	Relationships between vertical facial pattern, natural head position, and craniocervical posture in young Chinese children	Significant differences were found in natural head position (NHP) and craniocervical posture among vertical facial pattern subgroups in Chinese children with skeletal Class I relationship. High-angle (large NSL/ML) group → showed the largest values for most head position and craniocervical posture variables; posture characterized by extended head and craniocervical alignment.

To be continued

					Low-angle (small NSL/ML) group Symbol showed the smallest values for these variables; posture characterized by flexed head and craniocervical alignment. Mid-angle group values were intermediate.
Marchena-Rodriguez A et al. 2018	6–12 years (approximated from context)	189	Cross-sectional study	To evaluate the association between dental malocclusion and postural alterations in children	The study found possible associations between malocclusion and postural deviations, but due to the cross-sectional design, no causal relationships could be established. The authors suggest further longitudinal studies to clarify the nature of these associations.
Mason M. et al. 2018	6–12 years	41	Prospective interventional study with control group	To evaluate the effects of rapid palatal expansion (RPE) on posture and gait in subjects with maxillary transverse discrepancies	Significant posturographic and kinematic differences pre- and post-RPE; dynamic posture improved, especially in CbMono group
Neiva PD. et al. 2018	5-14 years	417	Systematic Review	Postural disorders in mouth breathing children: a systematic review	The review provides low evidence that mouth-breathing pattern in children between the ages 5-14 years is associated with postural deviations
Castellano M. et al. 2016	12.23 years	61	Comparative observational study	Craniofacial asymmetry in non-syndromic orthodontic subjects: clinical and postural evaluation	The results show a pelvic torsion angle of 1.08° + 3.00° (P = 0.0023) (normal value (NV) = 0.0-1.9°) in subjects presenting skeletal class II z asymmetry (control group: 1.17° ± 1.25°, not significant (NS)).
Vukicevic V. et al. 2016	8-14 years	90	Cross-sectional study	Relationship between head posture and parameters of sagittal position and length of jaws	Increased extension of the head in relation to the cervical spine can be a contributing factor to the formation of class II malocclusion
Šidlauskienė M. et al. 2015	7-14 years	94	Cross-sectional observational study	Relationships between Malocclusion, Body Posture, and Nasopharyngeal Pathology in Pre-Orthodontic Children	The study concluded that a significant link exists between the sagittal position of the mandible (SNB angle) and kyphotic posture, and that kyphotic posture is more frequent in patients with nasopharyngeal obstruction
Gogola A. et al 2014	8-14 years	336	Cross-sectional observational study	Assessment of connection between the bite plane and body posture in children and teenagers	Children with faulty postures present more intense malocclusions than children with a correct body posture. Results of this type suggest the need for interdisciplinary look at people with malocclusions whose therapy should involve body posture correction

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Kim P, et al 2014	6-18 years	38	Cross-sectional observational study	Cervical vertebral column morphology and head posture in preorthodontic patients with anterior open bite	Deviations in the cervical vertebral column morphology occurred in 23.7% of the subjects in the skeletal open-bite group and in 19.2% in the dentoalveolar open-bite group, but the difference was not significant. Head posture was significantly more extended in the skeletal open-bite group compared with the dentoalveolar open-bite group (craniovertical angle [Mx/VER], P <0.05; craniocervical angles [Mx/OPT, Mx/CVT], P <0.01. Only head posture was associated with craniofacial morphology: extended posture was associated with a large cranial base angle (P <0.01, P <0.001), large vertical craniofacial dimensions (P <0.05; P <0.01; P <0.001), and retrognathia of the jaws (P <0.001).
Segatto et al., 2014	7 - 16 years	69 (21 males, 48 females)	Observational cross-sectional	To investigate craniofacial and cervical morphology related to sagittal spinal posture in children and adolescents requiring orthodontic treatment	Data on craniofacial and cervical morphology correlated with sagittal spinal posture in the sample; specific results to be detailed if needed
Lopatienė K. et al 2013	12-14 years	76	Cross-sectional observational study	Investigate the relationships among orthodontic conditions, body posture, and nasopharyngeal obstruction in preorthodontic children	The prevalence of a poor body posture and a nasopharyngeal pathology was high in the present study. In total, 48.7% of the orthodontic patients had a kyphotic posture and 55.3% a rib hump in the thoracic region. The nasopharyngeal pathology was diagnosed in 78.9% of the patients. The patients with the kyphotic posture had a higher mandibular plane angle (MP-SN) and a lower sagittal position of the mandible SNB angle. A deeper overbite correlated with shoulder and scapular asymmetry. The kyphotic posture was diagnosed in 55.0% of the patients with the nasopharyngeal pathology.
Silvestrini-Biavati A. et al. 2013	8-12 years	605	Cross-sectional observational study	Clinical association between teeth malocclusions, wrong posture and ocular convergence disorders: an epidemiological investigation on primary school children	A prevalence of cases with an unphysiological gait was found in patients with overjet (14.70%) or overbite (14.87%), while the percentage of patients with normal occlusion that showed an unphysiological gait was 13.08%. Also, about 93.8%-94.2% of children showed normal legs without dysmetry, with no difference in respect to the type of occlusion. Subjects with an open bite or deep bite showed a slightly different distribution of right or left dominant eyes.

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Cerruto C. et al. 2012	9.2 years	23	Pilot study (RCT)	A computerized photographic method to evaluate changes in head posture and scapular position following rapid palatal expansion: a pilot study	In the study group a significant reduction in forward head posture (FHP) occurred between T0 and T1. Forward shoulder posture (FSP) decreased significantly between T1 and T2. At T1 treated patients exhibited significantly lower values of the measurements indicating FHP and FSP than controls.
Lippold C. et al 2012	**7.3** years	80	Randomized Clinical Trial	Spinal Deviations and Orthodontic Treatment of Asymmetric Malocclusions in Children	No clinically relevant differences were found between the control and treatment groups at T1 and T2 for the parameters of kyphotic and lordotic angles, surface rotation, lateral deviation, pelvic tilt, and pelvic torsion.
Perinetti G. et al. 2012	10.8-16.3 years	122	Cross-sectional observational study with multivariate analysis	Dental malocclusion and body posture	All of the posturographic parameters had large variability and were very similar between the two recording conditions. Moreover, a limited number of weakly significant correlations were observed, mainly for overbite and dentition phase, when using multivariate models
Springate S. D. 2012	11.76 years	59	Longitudinal observational study	Investigation of the relationship between head posture and craniofacial growth	The most prominent associations were between the change in cranio-cervical posture (CCP) and variables representing the growth directions of the mandible ($r = 0.72$, $P < 0.0001$); anterior maxilla ($r = 0.49$, $P < 0.001$); posterior cranial base ($r = 0.45$, $P < 0.01$); temporomandibular joint ($r = 0.56$, $P < 0.001$); and the change in postural height of the tongue ($r = 0.54$, $P < 0.0001$).
Arntsen T. et al., 2011	7–13 years	120	Cross-sectional observational study	To investigate the relationship between cervical vertebral column morphology, craniofacial morphology, and head posture in pre-orthodontic children with Class II malocclusion and horizontal maxillary overjet.	Children with altered cervical vertebral morphology showed significant differences in craniofacial morphology and head posture compared to those with normal cervical vertebrae. The study found associations but could not establish causality.
Pachi F. et al. 2009	12-18 years	55	Cross-sectional observational study	Head posture and lower arch dental crowding	The null hypothesis was rejected. A clear pattern of association was found between extended head posture and lower arch dental crowding

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Bevilacqua-Grossi D. et al. 2008	Not reporter	14	Comparative observational study	Assessment of head tilt in young children with unilateral posterior crossbite by video recording	Results suggest that unilateral posterior crossbite (PCB) could be related to the development of head tilt on the same side of the crossbite
Michelotti A. et al. 2008	12.3 years	1159	Cross-sectional analytical study	Unilateral posterior crossbite is linked to differences in leg length	Unilateral posterior crossbite does not appear to be associated with Limb length inequality (LLI), at least in young adolescents
Tecco S. et al. 2007	8–15 years	45	Randomized Controlled Trial	To evaluate changes in cervical posture following rapid palatal expansion over a 12-month follow-up	RPE group showed significant modifications in cervical posture compared to the untreated control group at 12 months; changes were assessed through cephalometric analysis
D'attilio M. et al. 2005	9,5 years	120	Cross-sectional observational study	Evaluation of Cervical Posture in Children with Skeletal Class I, II, and III	Significant differences were found in the inclination of the maxillary and mandibular bases relative to the spinal column among the three groups, indicating that neck posture is closely related to both the sagittal and vertical facial structure
Lippold C. et al. 2003	5 years	59	Cross-sectional observational interdisciplinary study	Interdisciplinary study of orthopedic and orthodontic findings in pre-school infants	The results suggest that identifying Angle Class II malocclusion in pre-school infants should prompt preventive screening. Early orthodontic treatment can help avoid incisor trauma, while also addressing possible orthopedic issues through interdisciplinary care
Solow B et al. 1998	7-13 years	96	Cross-sectional observational study	Head posture and malocclusions	A clear association was observed between anterior dental crowding and extended craniocervical posture. Individuals with more than 2 mm of crowding in the upper or lower anterior segments showed significantly larger craniocervical angles (by 3–5 degrees) compared to those without crowding. These findings support the soft tissue stretching hypothesis, suggesting that increased dorsally-directed soft tissue pressure in individuals with an extended head posture may hinder the sagittal development of the dentoalveolar arche
Solow B. et al. 1992	9.9 years	34	Prospective longitudinal observational study	Cervical and craniocervical posture as predictors of craniofacial growth	Indicating that a small craniocervical angle and a posteriorly inclined upper cervical spine at time 1 were associated with horizontal facial development

Results

Due to the marked heterogeneity of the included studies in terms of design, population, measured postural and occlusal parameters, and assessment methods (photogrammetry, radiography, podometric analysis, cephalometric analysis), it was not possible to perform a conventional meta-analysis based on effect size measures (odds ratio, standardized mean difference, hazard ratio) and their confidence intervals.

Numerous studies have reported solely p-values or correlations without providing comprehensive descriptive statistics (such as mean, standard deviation, and sample size per group), thereby hindering the standardization of effect sizes.

Consequently, the quantitative synthesis relied on:

- **A structured descriptive synthesis** is organized by type of malocclusion, postural alteration, and cephalometric parameter, reporting for each study the main results, the direction of the association, and the level of statistical significance.
- **A systematic evaluation of methodological quality** and risk of bias is conducted utilizing frameworks such as STROBE, Jadad, AMSTAR 2, along with specialized instruments including AXIS, ROB 2, and ROBIS.

Statistical Analysis — Quantitative Synthesis of p-values

A total of 58 p-values were manually extracted from the Results sections of 30 included studies, encompassing cross-sectional, longitudinal, and randomized designs. Due to heterogeneity in study designs, the p-values were synthesized without weighting by sample size or study quality and should be regarded as exploratory rather than confirmatory. These values were obtained from various statistical tests reported by the authors, including Student's t-test, χ^2 test, ANOVA/MANOVA, correlation analyses, and logistic regression models.

All p-values were converted into decimal format. Implausible values ($p \leq 0$ or $p > 1$) and descriptive statements lacking numeric p-values (e.g., "not significant" without a reported p) were excluded. When multiple p-values pertained to the same test but different outcomes, each was maintained separately to accurately represent the distribution of evidence.

Fisher's Method

The combined statistic was calculated as: $\mathbf{X^2 = -2 \sum \ln(p_i)}$ where k represents the number of included studies. Applying this method to the collected data yielded a combined p-value < 0.0001, indicating highly significant overall evidence.

Stouffer's Method (Unweighted)

Each p-value was transformed into a standardized Z-score and combined as follows: $\mathbf{Z = (\sum Z_i) / k}$. This methodology, which exhibits greater sensitivity to the overall distribution of p-values rather than solely focusing on extreme values, yielded a combined p-value approximately equal to 1.0, thereby indicating a high proportion of studies with non-significant outcomes.

The distribution pattern of the extracted p-values indicated a small cluster of studies with exceptionally low values ($p < 0.01$), alongside a majority exceeding the conventional significance threshold ($p > 0.05$).

Table 3. Quantitative Synthesis of p-values.

Combination Method	Combined p-value	Interpretation
Fisher	< 0.0001	Highly significant evidence, driven by the smallest p-values
Stouffer (unweighted)	≈ 1.0	No overall significance, reflects the global distribution of the data

Interpretation

The pronounced distinction between the findings of Fisher and Stouffer indicates that, although certain individual studies demonstrate strong statistical significance, the majority of the available evidence does not substantiate a consistent or statistically significant association. Fisher's method, which is sensitive to small p-values, emphasizes the impact of a few highly significant results, whereas Stouffer's method, offering a more balanced perspective, mirrors the general absence of statistical significance.

Given the absence of uniform effect size data and the reliance on p-values alone, these findings should be interpreted with caution. The primary strength of this review lies in the qualitative synthesis and methodological quality assessment, which provide a critical framework for future high-quality studies that should report effect sizes and confidence intervals to enable robust quantitative meta-analysis.

Descriptive Results of Included Studies

Dental Occlusion and body posture

- Subjects exhibiting **Class II malocclusion** (2, 9, 34) frequently present with:
  - Forward head posture
  - Increased cervico-dorsal angle
  - Kyphotic trunk posture
  - Posterior pelvic tilt
- Subjects with **Class III malocclusion** (31) tend to present:
  - Head extension
  - Posterior trunk inclination
  - Increased lumbar lordotic angle
- **Crossbite** (4, 26, 33) is associated with:
  - Shoulder asymmetry
  - Lateral trunk deviation
  - Pelvic rotation
- **Dental crowding** (28, 29) correlates with:
  - Increased mandibular inclination
  - Anterior chin projection
  - Alterations in SNB and MP-SN angles

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Foot Support and Global Posture

- Subjects with **malocclusion** (24) show:
  - Altered Foot Posture Index (FPI)
  - Asymmetric plantar support
  - Increased forefoot pressure
  - Reduced Clarke angle (indicative of flatfoot)
- Additional findings (7) include:
  - Correlation between open bite and rearfoot valgus
  - Relationship between increased overjet and postural instability
  - Lateral shift of the center of gravity in deep bite cases

Cephalometric parameters and cranio-cervical posture

- Subjects with **Class II malocclusion** (2, 15, 34) present:
  - Increased NSL/CVT angle (>106°)
  - Reduced NL/OPT angle (<90°)
  - Pronounced mandibular inclination
- In **mouth breathers** (6, 21):
  - Increased cranio-cervical angle (NL/OPT)
  - Reduced SNB angle (<76°)
  - Maxillary protrusion
- Subjects with **crossbite** show (25, 33):
  - Mandibular asymmetry
  - Chin deviation
  - Altered interincisal angle

Several studies documented quantitative metrics that were omitted from the meta-analysis, such as moderate correlations between cranio-cervical posture and occlusal parameters (r = 0.42–0.48) (35), and notable differences in pelvic inclination between individuals with and without dental crowding (Cohen's d = 0.72) (7). These quantitative measures were excluded from the meta-analysis owing to incomplete reporting of essential descriptive statistics required for effect size standardization.

Table 4. Types of malocclusion related to postural associations.

Type of malocclusion	Total studies	Positive association	Negative association
Class I, II, III	4	4	0
Overjet / Overbite	3	3	0
Posterior Crossbite	2	1	1
Dental Crowding	2	2	0
Class II with Asymmetry	1	1	0
Asymmetric Classes	1	0	1
Skeletal Open Bite	1	1	0
Severe malocclusion	1	1	0

Numerous studies conducted on pediatric and adolescent populations highlight that the relationship between cranio-cervical posture and sagittal malocclusions is characterized by complex biomechanical adaptations specific to each skeletal class. In particular, Class II malocclusion is frequently associated with increased cervical curvature and a more extended head posture, with cranial measurement angles such as the angle between the Nasion-Sella line and the cervical vertebra tangent (NSL/CVT), and between the odontoid process tangent and the horizontal reference line (OPT/HOR) significantly altered in subjects with Class II malocclusion compared to controls. These postural changes may reflect functional compensatory mechanisms aimed at maintaining postural balance and optimizing respiratory function (11).

Conversely, individuals with Class III malocclusion tend to demonstrate a straighter cervical spine and a more forward head position, with diminished cervical inclinations that may mitigate the mandibular protrusion characteristic of this classification. Cephalometric and three-dimensional evidence substantiate notable differences in head-neck posture angles (e.g., SN-Ver, MCA) and the positioning of the hyoid bone, which is located more posterior-inferiorly in Class II subjects and more anteriorly in Class III subjects.

Importantly, the influence of growth phases on postural adaptation patterns has been underscored, revealing the necessity of a dynamic and temporal assessment of malocclusion effects on cranio-cervical posture throughout development. Children with faulty postures present more intense malocclusions than children with a correct body posture (12). Analysis of the natural head position (NHP) reveals variations related to skeletal class that may have important implications for orthodontic and orthognathic treatment planning in children and adolescents.

Table 5. Postural alteration related to malocclusion and orofacial dysfunction

Type of postural alteration	Total studies	Positive association	Negative association
Cervical	5	5	0
Pelvic	2	2	0
Foot	1	1	0
Leg length discrepancy	1	0	1
Trunk/body posture	3	3	0
Cranio-cervical	4	4	0
Posturographic parameters	1	0	1

Segatto et al. (33) investigated craniofacial and cervical morphology in relation to sagittal spinal posture within a pediatric and adolescent demographic, emphasizing the interconnectedness of cranio-cervical structures and spinal alignment throughout growth.

Brożek-Mądry et al. examined the association between a short lingual frenulum and forward head posture in children at risk of obstructive sleep apnea syndrome (OSAS) (6). Their findings show that children with a short frenulum exhibit increased forward head posture and a higher prevalence of high-arched palate. This suggests that ankyloglossia may lead to compensatory postural changes related to airway function, highlighting the importance of early diagnosis to prevent orofacial and postural alterations.

These data reinforce the notion that cranio-cervical posture in pediatric and adolescent patients should be viewed not merely as a descriptive parameter but as an essential element within a complex system of biomechanical and functional adaptations that influence craniofacial development and occlusal stability during growth.

Limitations

Despite a comprehensive search including published and grey literature, this review faces several limitations: Methodological heterogeneity across included studies regarding design, sample size, and postural assessment techniques limits comparability and generalizability. The majority of studies are observational and cross-sectional, restricting causal inference and longitudinal insights. However, some RCTs and longitudinal studies strengthen the overall evidence quality. Lack of standardized, objective postural metrics and limited control for confounding factors (e.g., visual, vestibular, respiratory influences) reduce internal validity. Potential publication bias and geographic concentration of studies may affect representativeness. Several potentially relevant studies were excluded based on predefined criteria, including participant age outside the pediatric range. Details of these excluded studies have been retained in the project archive for transparency and future reference. Absence of standardized effect size data prevented formal meta-analysis.

Grade assessment

The overall quality of evidence is moderate. While methodological heterogeneity limits generalizability, clinical consistency and biomechanical plausibility support the conclusions. Future research should prioritize standardized methods and longitudinal designs to enhance evidence robustness.

Assessment of Methodological Quality and Risk of Bias

Methodological assessment of quality (STROBE, Jadad Scale, AMSTAR 2)

STROBE

The majority of the observational studies included in this review demonstrate a moderate methodological quality based on the STROBE criteria. Objectives are generally well articulated, and descriptions of populations are adequate, although in certain instances, the sample sizes are limited or not entirely representative. Postural measurement techniques exhibit considerable variability: some studies utilize objective tools such as rasterstereography or radiography, while others depend on more subjective methodologies, including clinical photography or direct observation. This variability contributes to methodological heterogeneity, which restricts comparability across studies. Statistical analyses are predominantly descriptive, with only a few studies employing multivariate models to account for confounding variables. The absence of adjustments for variables such as visual input (5,13,33), vestibular function, or respiration constitutes a common methodological limitation. Certain studies, such as those by Perinetti et al. (31) and Kim et al. (14), stand out for their moderate-to-high quality owing to more comprehensive reporting and more robust statistical analyses. Conversely, studies such as Cerruto et al. (8) and Bevilaqua-Grossi et al. (4) exhibit significant limitations, including poorly defined objectives, small sample sizes, and measurement methods lacking validation. Overall, the quality of reporting is sufficient to support the narrative synthesis of this review but underscores the necessity for future research to adopt more standardized and methodologically rigorous approaches.

Jadad Scale

Lippold et al. (17) achieved a Jadad score of 3 out of 5. This score indicates a study of moderate methodological quality. While the randomization process and reporting of attrition are conducted with robustness, the lack of blinding presents a potential risk of bias. Nevertheless, the utilization of objective measurement tools (e.g., rasterstereography) may alleviate some concerns associated with detection bias.

Cerruto et al. (8) attained a Jadad score of 2/5. This score signifies a study of low to moderate methodological quality. Although the trial is randomized and participant selection is well-documented, the absence of blinding and insufficient details concerning the randomization process present potential risks of bias. Nevertheless, the application of objective, computerized photographic measurements may alleviate some concerns associated with detection bias.

Tecco et al. (36) achieved a Jadad score of 2/5, indicating a study of low to moderate methodological quality. Although the trial is described as randomized and reports complete follow-up without attrition, the absence of a detailed randomization procedure and the lack of blinding may introduce potential biases. Nonetheless, the employment of objective cephalometric measurements could mitigate concerns related to detection bias.

AMSTAR 2

Di Palma et al. (11) received a moderate overall confidence rating. The review is well conducted in several key methodological domains but exhibits some limitations, including the absence of a registered protocol, lack of a detailed list of excluded studies, and the inability to perform a meta-analysis due to heterogeneity among included studies. The synthesis remains descriptive, with acknowledged limitations and

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Table 6. Risk of Bias (AXIS, Rob 2, ROBIS).

Author and year	Study design	Main Methodological Limitations	Risk of bias
Di Palma G. et al. 2025	Systematic Review	Review well conducted in key methodological domains; limitations include absence of registered protocol, no detailed list of excluded studies, and inability to perform meta-analysis due to heterogeneity.	Moderate. Due to descriptive synthesis with acknowledged limitations and acceptable transparency.
Morales-Atarama P et al. 2025	Cross-sectional study	Small sample size (n=37) and limited age range. Lack of details on posture and malocclusion assessment methods.	Moderate-High. Possible selection and measurement bias, no follow-up.
Bardellini E. et al. 2022	Prospective longitudinal Interventio-nal study	Interventional longitudinal study but unspecified number. Lack of control group.	Moderate. Lack of control and possible placebo effect.
Brożek-Mądry E et al., 2021	Observational cross-sectional study	Limited sample size justification; possible selection bias; limited control of confounders	Moderate. Due to potential selection bias from PSQ-based recruitment, lack of control for confounders, single-examiner assessments without reliability checks, small sample size, and cross-sectional design limiting causal conclusions.
Klostermann I. et al 2021	Retrospective observational	Retrospective study, possible selection bias. Small size (n=55).	Moderate-High. Retrospective design.
Liu Y. et al. 2018	Cross-sectional observational study	Relationships between vertical facial pattern, natural head position, and craniocervi-cal posture in young Chinese children	Moderate. However, recruitment from a single orthodontic clinic and lack of confounder adjustment limit generalizability and internal validity.
Marchena-Rodriguez A et al. 2018	Cross-sectional study	Cross-sectional (n=189). Possible associations but not causal.	Moderate. Decent size but no follow-up.
Mason M. et al 2018	Prospective interventional study with control group	Prospective study with control group, small sample (n=41). Complex postural parameters subject to variability.	Moderate. Control and follow-up but limited sample.
Neiva DP. et al. 2018	Systematic Review	Systematic review with limited evidence. Low quality of included studies.	Moderate. Based on quality of original studies.

To be continued

Castellano M. et al., 2016	Cross-sectional observational study	Cross-sectional design; potential variability in postural assessment measurements; no sample size calculation reported; lack of adjustment for confounders.	Moderate. Measurement variability and absence of statistical power calculation limit precision, while no control for confounders affects result validity.
Vukicevic V. et al. 2016	Cross-sectional observational study	Cross-sectional (n=90). Subjective posture assessment.	Moderate. Small sample, limited design.
Šidlauskienė M. et al. 2015	Cross-sectional observational study	Cross-sectional (n=94). Possible variability in diagnosis of nasopharyngeal obstruction.	Moderate. Good interdisciplinarity, but observational design.
Gogola A. et al 2014	Cross-sectional observational study	Large cross-sectional (n=336). Lack of causal analysis.	Moderate. Good size but associative design.
Kim P, et al 2014	Cross-sectional observational study	Cross-sectional (n=38). Small groups and possible confounders.	Moderate-High. Small sample, observational design.
Segatto et al., 2014	Cross-sectional observational study	Cross-sectional design limits causal inference; potential selection bias; no longitudinal follow-up; limited confounder adjustment	Moderate risk: Good methodology for cross-sectional, but limited by design and potential confounders
Lopatienė K. et al 2013	Cross-sectional observation-nal study	Cross-sectional (n=76). Subjective measures of posture and nasopharyngeal pathology.	Moderate. Interdisciplinary method but associative.
Silvestrini-Biavati A. et al. 2013	Cross-sectional observation-nal study	Epidemiological study on large population (n=605). Small effects and unclear distribution.	Moderate. Good size but descriptive data.
Cerruto C. et al. 2012	Pilot study (Randomized Controlled Trial)	Pilot study with small sample (n=23). Lack of a robust control group.	High. Small sample and pilot design.
Lippold C. et al 2012	Randomized Clinical Trial	Randomized clinical trial (RCT) positive, but only two measurement points (T1 and T2). Potential limitation in the number of evaluated parameters.	Low-Moderate. Well-conducted RCT, but sample size and follow-up not detailed.
Perinetti G. et al. 2012	Cross-sectional observational study with multivariate analysis	Cross-sectional (n=122). High variability in postural parameters.	Moderate-High. Unstable parameters and associative.

To be continued

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Springate S. D. et al. 2012	Longitudinal observational study	Longitudinal study (n=59). Complex parameters and variable dependency.	Low-Moderate. Longitudinal, good statistical analyses.
Arntsen T. et al. 2011	Cross-sectional observational study	Cross-sectional, therefore unable to establish causality. Possible variability in vertebral morphology assessment. Decent sample size, but specific (Class II with overjet).	Moderate. Good sample, but observational design.
Pachi F. et al., 2009	Cross-sectional observational study	Cross-sectional design; postural assessment subject to variability; relatively small sample size; lack of stratification by age or gender.	Moderate. The small, non-stratified sample and variable-dependent measurement reliability may lead to biased or imprecise associations.
Bevilacqua-Grossi D. et al., 2008	Cross-sectional observational study	Cross-sectional design, therefore causality cannot be established; potential selection bias; relatively small sample size; no adjustment for potential confounding variables.	Moderate. The inability to establish temporal relationships and lack of confounder adjustment reduce internal validity despite appropriate measurement techniques.
Michelotti A. et al., 2008	Cross-sectional observational study	Cross-sectional design; specific sample (adolescents) limiting generalizability; possible selection bias; no control for potential confounders.	Moderate. Targeting a narrow age group enhances internal consistency but limits external validity; uncontrolled confounding variables remain a concern.
Tecco S. et al. 2007	Randomized controlled trial	Method of randomization not described; allocation concealment unclear; blinding of outcome assessors not reported; single-operator treatment may introduce performance bias; only female participants (reduced external validity)	Some concerns
D'Attilio M. et al., 2005	Cross-sectional observational study	Cross-sectional design; potential measurement errors; limited sample size; absence of follow-up; no inter-examiner reliability assessment.	Moderate. Lack of reliability checks and small sample size increase the risk of random error and reduce reproducibility.
Lippold C. et al. 2003	Cross-sectional observational interdisciplinary study	Cross-sectional on infants (n=59). Lack of longitudinal data.	Moderate. Specific sample but cross-sectional.

To be continued

Solow B et al. 1998	Cross-sectional observational study	Cross-sectional (n=96). Traditional method with limited technology.	Moderate. Good statistical analysis but associative.
Solow B. et al. 1992	Prospective longitudinal observational study	Small sample size (n=34). Limited generalizability due to specific age and population.	Moderate. Longitudinal design but limited sample.

an acceptable level of transparency. The systematic review was included in accordance with the predefined inclusion criteria; however, to maintain consistency with the pediatric and adolescent focus, only data pertaining to subjects aged 0 to 18 years were considered. This approach ensured homogeneity of the studied population and allowed for analysis of postural adaptations specific to growth phases.

Neiva et al. (28) state that, according to AMSTAR 2 guidelines, the presence of multiple weaknesses in critical domains—specifically the lack of protocol registration, the absence of documentation regarding excluded studies, and the omission of publication bias assessment results—results in a low overall confidence in the findings of the review. While the narrative synthesis is coherent and methodologically sound within its scope, the absence of key safeguards against bias diminishes the reliability and generalizability of the conclusions.

Discussion

Despite the lack of consistent statistical significance across the whole body of evidence, the presence of isolated studies with highly significant results suggests that specific postural and occlusal relationships may hold clinical relevance. In particular, the associations observed in studies with extremely low p-values, though not representative of the entire dataset, may reflect genuine biomechanical or functional interactions that are observable in practice.

From a clinical perspective, these findings highlight the significance of incorporating postural assessment into pediatric dental and orthodontic practice (3, 9, 36). Although the aggregated data do not substantiate a universal or strong correlation, the presence of specific effects in certain populations (e.g., Class II malocclusion with forward head posture (6), pelvic asymmetries associated with dental crowding) may warrant individualized evaluation and interdisciplinary collaboration between orthodontists and physiotherapists specializing in posturology.

Ultimately, the existing evidence underscores the necessity for future research incorporating standardized methodologies, objective postural measurements, and explicitly defined occlusal classifications. Such investigations would enable clinicians to transcend anecdotal observations and adopt evidence-based protocols that integrate postural evaluation into dental and orthodontic practices (23).

Summary of key findings: tongue function, occlusion, and posture

this review underscores the intricate and reciprocal relationship among tongue function, dental occlusion, and postural alignment, especially in developing individuals. Given its central role in swallowing, respiration, and phonation, the tongue can influence myofascial chains and impact overall posture (27). Evidence indicates that dysfunctions such as a short lingual frenulum and mouth breathing are correlated with cervical and scapular modifications, whereas malocclusions like unilateral crossbite may affect limb symmetry and balance. It is recommended to conduct early screening for Class II malocclusions during preschool years (18), thereby emphasizing the significance of prompt interdisciplinary assessment.

The cervical spine serves as a vital anatomical connection between craniofacial structures and overall posture. Cervical posture is predictive of craniofacial development (32), and vertical growth patterns also influence cranio-cervical posture (20), thereby adding complexity to diagnostic assessments. Research has demonstrated that skeletal anomalies and malocclusions can affect cervical vertebral morphology and head orientation. Orthodontic interventions, such as rapid palatal expansion, may have a positive impact on cervical posture (36), although the methodological quality of evidence varies. Additionally, plantar posture is altered in children with malocclusions (24), indicating a broader influence on overall posture beyond the craniofacial region.

Head posture is intricately linked to occlusal patterns. Variations in head positioning are frequently observed in cases of open bite, crossbite, and dental crowding. Such modifications may represent compensatory mechanisms or could potentially worsen dysfunction. Interventions focused on occlusal correction have shown promise in affecting head and scapular posture (3)(8), suggesting possible therapeutic advantages.

Furthermore, vertebral posture, including thoracic kyphosis and pelvic torsion, has been linked to nasopharyngeal obstruction and craniofacial asymmetries (21)(7). The sagittal alignment of the spine may reflect or aggravate occlusal discrepancies, indicating a broader systemic involvement. Several studies suggest that reducing overjet or rectifying skeletal Class II malocclusion can impact pelvic rotation and spinal equilibrium (15)(37).

Postural rehabilitation approaches, such as global postural re-education, have shown promise in improving

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both musculoskeletal alignment and stomatognathic function (5). These findings support the integration of orthodontic and postural therapies, especially in pediatric populations where growth modulation is still possible.
In conclusion, the literature supports an integrated view of the stomatognathic system and posture, emphasizing the need for multidisciplinary collaboration in diagnosis and treatment. However, variability in study design and assessment methods calls for more rigorous research to clarify causal relationships and optimize clinical strategies.

Table 7. Correlations between malocclusion, tongue, oral disfunction and body posture.

Type of Malocclusion / Dysfunction	Associated Postural Alteration	Strength of Association	Clinical Notes
Class II malocclusion	Forward head posture, cervical inclination	Moderate	Supported by cross-sectional and longitudinal studies
Class III malocclusion	Head extension, posterior trunk inclination	Weak–Moderate	Limited evidence, variable findings
Increased overjet	Postural instability, center of gravity shift	Moderate	Significant posturographic findings
Dental crowding	Mandibular inclination, chin projection	Moderate	Correlations with cephalometric angles
Posterior crossbite	Scapular asymmetry, lateral trunk deviation	Weak–Moderate	Observed in comparative studies
Open bite	Head extension, cervical alignment changes	Moderate	Linked to cranio-cervical posture
Short lingual frenulum	Cervical and scapular alterations	Moderate	Involves myofascial and respiratory mechanisms
Mouth breathing	Kyphotic posture, maxillary protrusion	Moderate	Evidenced in systematic reviews
Asymmetric malocclusion	Mandibular deviation, pelvic tilt	Weak	Inconsistent findings across studies

Conclusions

Postural regulation during childhood is a dynamic process that evolves concurrently with skeletal maturation, neuromuscular coordination, and sensorimotor integration. The stomatognathic system, particularly the tongue and dental occlusion, interacts with these developmental processes subtly yet potentially significantly. During growth, compensatory mechanisms may arise to adapt to functional imbalances such as altered tongue posture or malocclusion, which can influence cervical alignment, scapular symmetry, and pelvic orientation.
Given the inherent plasticity of the musculoskeletal system in pediatric populations, early identification of dysfunctions within the stomatognathic system offers a valuable opportunity for preventive intervention. Addressing these dysfunctions during critical growth periods may mitigate the risk of long-term postural deviations and associated musculoskeletal complications.
The relationship between craniofacial structures and posture extends beyond direct mechanical effects. Although the stomatognathic system is not classified as a primary postural receptor, it may serve as a source of biomechanical and neuromuscular interference, particularly within the cervical region. The tongue, while not universally recognized as a determinant of global postural imbalance (6, 26), plays a pivotal role in cervical alignment and foundational functions such as respiration and swallowing. Its integration within myofascial chains further supports its potential significance in postural regulation, especially in cases involving a short lingual frenulum (26).
These findings emphasize the significance of evaluating both functional and anatomical aspects of the stomatognathic system in the assessment of postural patterns and the development of therapeutic interventions (30). Notably, visual input, particularly ocular function, exerts a substantial influence on postural control, yet it remains largely neglected in studies investigating the interaction between posture and the stomatognathic system (5,13, 35). This lacuna in the literature underscores the necessity for future research to incorporate visual parameters, thereby enhancing the understanding of the complex interplay among sensory and anatomical systems involved in postural regulation.
In summary, the stomatognathic system, particularly the tongue, should be considered not solely in terms of oral function but also as a potential contributor to postural dynamics (22). A multidisciplinary approach involving dentists and physiotherapists specialized in posturology may prove beneficial not only for treatment but also as a preventive strategy during critical phases of growth and development. Interdisciplinary collaboration can facilitate early identification of compensatory mechanisms and

support integrated care pathways aimed at optimizing both functional and postural outcomes.

Clinical recommendations

Based on the current body of evidence and clinical insights, it is advisable to integrate postural screening into routine orthodontic evaluations, with particular attention to cervical and craniofacial posture in cases of Class II malocclusion, Class III malocclusion, cross bite, open bite, or tongue dysfunction. Establishing collaborative referral pathways among orthodontists, physiotherapists, and speech therapists is essential to ensure comprehensive assessment and management of stomatognathic and postural dysfunctions. Monitoring postural changes closely during rapid growth phases, such as prepubertal periods, is critical, as compensatory mechanisms may become more pronounced. Thus, these clinical recommendations should be applied cautiously and adapted to individual patient contexts. Additionally, educating families on functional habits including breathing patterns, tongue posture, and oral behaviours that influence occlusion and posture can enhance preventive efforts. Early identification and management of tongue-related dysfunctions, such as short lingual frenulum or low resting posture, may reduce the risk of persistent postural imbalances.

Future directions

To advance understanding and improve clinical application, future research should prioritize the standardization of assessment protocols by developing and adopting unified, validated, and reproducible tools for evaluating both stomatognathic and postural parameters. Incorporating multisensory analyses that include visual, vestibular, and proprioceptive inputs will better capture the complexity of postural regulation. Longitudinal studies tracking changes over time particularly before and after orthodontic or myofunctional interventions are warranted to clarify causality and therapeutic impact. Furthermore, reporting effect sizes and confidence intervals alongside p-values is essential to quantify the magnitude and clinical relevance of observed associations. Finally, investigating preventive strategies aimed at early identification and correction of stomatognathic dysfunctions may offer critical insights into reducing the incidence of long-term postural deviations.

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