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Review article

Mouth Breathing Revisited: A Functional Disorder Linking Airway Physiology, Craniofacial Development, and Clinical Management

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Abstract
Mouth breathing (MB) is a prevalent breathing pattern observed in both pediatric and adult populations. Although often regarded as a benign habit, growing evidence indicates that chronic MB represents a maladaptive functional disturbance with significant systemic and oral health implications. This narrative review synthesizes current evidence on the pathophysiology of MB, its effects on craniofacial development and orofacial function, and contemporary approaches to diagnosis and management, while highlighting important regional gaps in the literature. A comprehensive literature search was conducted across major electronic databases, including PubMed, Scopus, and Web of Science. To enhance retrieval sensitivity and ensure broader coverage, supplementary searches were performed using Google Scholar, alongside manual screening of reference lists of relevant articles. Available evidence consistently associates chronic MB with impaired nasal breathing, altered orofacial muscle function, characteristic craniofacial changes, and functional disturbances. It is also associated with sleep-disordered breathing and reduced oral health-related quality of life. Emerging evidence further links it to temporomandibular joint dysfunction and cervical muscle impairment, likely mediated by postural adaptation and altered neuromuscular coordination. Epidemiological and functional data from regions such as Libya remain limited, with existing research predominantly focused on structural dental outcomes rather than airway- related determinants. MB should be recognized as a modifiable functional disorder with multisystem effects. Standardized diagnostic criteria, longitudinal studies, and region-specific epidemiological investigations, particularly in underrepresented settings, are essential to advance evidence-based and contextually relevant clinical practice.
Keywords. *Mouth Breathing, Craniofacial Development, Nasal Obstruction, Malocclusion.*

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Introduction

Breathing is fundamental to physiological homeostasis, regulating gas exchange, blood pH, and oxygen delivery to tissues. Beyond its primary respiratory role, breathing patterns influence autonomic balance, cardiovascular function, and neurophysiological activity [1,2]. Under normal conditions, nasal breathing is the physiologically optimal route, providing filtration, humidification, and temperature regulation of inspired air, while also contributing to optimal airflow dynamics and nitric oxide-mediated pulmonary processes [3-5]. Chronic mouth breathing disrupts these mechanisms, with evidence suggesting alterations in oxygen-carbon dioxide balance and reduced nitric oxide bioavailability. Emerging evidence suggests associations with airway irritation, inflammatory responses, and possible alterations in autonomic regulation, with potential systemic implications [2,6]. MB often develops as a compensatory response to nasal obstruction, such as allergic rhinitis, adenoid hypertrophy, tonsillar enlargement, or structural nasal abnormalities, but may persist after resolution of the primary cause, evolving into a habitual or neuromuscular pattern that can independently affect orofacial function and craniofacial development [7-9].

Clinically, MB has been linked to altered respiratory mechanics and sleep-disordered breathing, with potential neurocognitive and behavioral consequences [10-12]. Within this broader physiological context, MB is particularly relevant in dentistry and orthodontics due to its association with dentofacial morphology, reflecting altered orofacial muscle activity, abnormal tongue posture, and disrupted functional stimuli during critical growth periods [13-15]. Although several studies report associations between MB and specific craniofacial features, findings remain heterogeneous and limit definitive conclusions [14,15].

Within this broader framework, MB is increasingly recognized as a clinically relevant functional disorder with implications for respiratory physiology, craniofacial development, and overall health. It frequently coexists with other oral habits, including non-nutritive sucking and dysfunctional swallowing patterns, suggesting a broader context of orofacial functional imbalance [16]. Although MB has been explored across diverse populations, its relationship with demographic factors remains inconclusive, with conflicting evidence regarding sex distribution and socioeconomic influences [17-19]. Epidemiological data indicate

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substantial variability in prevalence, ranging from 5% to 75% in children, likely reflecting heterogeneity in diagnostic criteria and study populations [14,20]. A meta-analysis reported a pooled prevalence of deleterious oral habits of 28.9%, with MB accounting for 21.1% of cases, particularly among children aged 6-12 years [21]. Overall, habitual or intermittent MB may affect up to 30-50% of children and is commonly associated with airway obstruction or obstructive sleep apnea [22].

These findings underscore the clinical importance of early identification and comprehensive evaluation, as MB often represents not merely a benign habit but a manifestation of underlying airway compromise with potential long-term functional and developmental consequences. However, despite growing international interest, important regional gaps persist. Research on MB in Libya remains limited. Existing studies have largely focused on dental caries and periodontal disease, with minimal attention to functional determinants such as breathing patterns [23-25]. Available epidemiological data indicate a high prevalence of malocclusion, including crowding, maxillary constriction, and anterior open bite features often reported in association with chronic MB [26,27]. Although causality cannot be established, these findings suggest that MB may represent an underrecognized factor in craniofacial development, occlusion patterns, and oral health. These considerations highlight the importance of incorporating airway assessment into routine dental and orthodontic evaluation and underscore the need for an interdisciplinary approach to management. This narrative review aims to synthesize current evidence on MB, focusing on its pathophysiology, impact on craniofacial development, and associated functional and quality-of-life outcomes, while outlining contemporary approaches to diagnosis and management.

Pathophysiologic Consequences

MB represents a fundamental disruption of normal respiratory physiology, with consequences that extend beyond the orofacial region to affect systemic homeostasis and airway defense mechanisms [3,6]. In MB, inhaled air reaches the lower respiratory tract inadequately conditioned, leading to mucosal dryness, increased airway irritation, and heightened susceptibility to infections. The loss of nasal filtration permits greater entry of allergens and particulate matter, potentially exacerbating inflammatory conditions [6]. Nasal breathing facilitates the delivery of endogenously produced nitric oxide (NO) from the paranasal sinuses into the lower airways [3]. NO plays a key role in pulmonary vasodilation, antimicrobial defense, and optimization of ventilation-perfusion matching [4,5]. MB reduces NO availability, which may impair oxygen uptake efficiency and contribute to suboptimal arterial oxygenation, particularly during sleep [6].

MB is associated with altered respiratory patterns, often characterized by shallow, rapid breathing and increased reliance on accessory muscles. This dysfunctional pattern reduces diaphragmatic efficiency and may increase the work of breathing [2]. Over time, such alterations can contribute to fatigue, reduced exercise tolerance, and impaired respiratory endurance [28].

Chronic MB is strongly associated with sleep-disordered breathing, including obstructive sleep apnea and snoring. The transition to mouth airflow promotes airway instability and collapsibility during sleep [10,11,14]. These disturbances can result in intermittent hypoxia, fragmented sleep architecture, and dysregulation of neuroendocrine function, with downstream effects on cognition, behavior, and cardiovascular health [2,28].

Beyond its effects on respiratory and sleep physiology, nasal breathing also appears to play a role in central neural regulation. Emerging evidence suggests that nasal breathing rhythmically modulates neural activity within the hippocampus and prefrontal cortex, regions critical for memory, attention, and executive function [29,30]. Disruption of nasal airflow, as occurs in chronic MB, may therefore interfere with these neurophysiological processes. This mechanism may, in part, explain the cognitive, behavioral, and academic difficulties frequently reported in children with persistent MB [30,31].

To maintain airway patency, individuals who breathe through the mouth often assume compensatory positions, most notably a forward head posture. This adaptation disrupts the functional balance between the muscles of the face, mouth, and neck, increasing mechanical stress and the likelihood of musculoskeletal dysfunction and pain. Over time, these changes may establish a self-sustaining compensatory cycle in which altered muscle tone and coordination between the jaw, tongue, and cervical muscles compromise the stability and integrity of the craniofacial and cervical systems [31-33].

Impact of MB on the Maxillofacial Complex

Craniofacial development is governed by a dynamic interaction between genetic determinants and functional stimuli, particularly nasal respiration, tongue posture, and coordinated orofacial muscle activity; disruption of this balance leads to characteristic dento-craniofacial adaptations [13,34]. Chronic MB disrupts the functional equilibrium of the orofacial complex, leading to characteristic craniofacial adaptations driven by altered muscle dynamics and tongue posture [12,35]. Reduced tongue-to-palate contact diminishes the

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lateral expansive forces required for normal maxillary development, while increased buccinator activity exerts inward pressure on the dental arches, resulting in a constricted maxillary arch and a high-arched, narrow palate [15,16]. These changes contribute to posterior crossbite, dental crowding, and reduced nasal cavity volume, further perpetuating airway compromise [4]. Concurrently, chronic lip incompetence and perioral muscle imbalance reduce the restraining influence on dentoalveolar structures. This promotes excessive eruption, increased lower anterior facial height, mandibular clockwise rotation, and a tendency toward skeletal open bite features commonly described as “long face syndrome” [14,34,35]. Altered tongue posture and downward and posterior mandibular positioning are associated with Class II skeletal relationships and may be associated with retrognathia by limiting functional stimulation of mandibular growth [36-38].
These structural changes are accompanied by functional impairments in mastication, swallowing, and speech, with atypical patterns such as tongue thrust further reinforcing malocclusion [37,38]. Soft tissue adaptations, including upper lip hypotonicity and mentalis hyperactivity, both reflect and reinforce these skeletal imbalances [35,39]. Importantly, these alterations form a self-reinforcing cycle in which reduced maxillary width, increased palatal height, and mandibular retrusion further compromise nasal airway patency, supporting the principle that function influences craniofacial form “*Function Modifies Anatomy*” [13,35].

Table 1. Classification and Clinical Interpretation of Mouth Breathing (MB)

Aspect	Description	Clinical Interpretation
Disease status	Not recognized as an independent disease entity in current classifications	Considered a clinical sign or functional breathing pattern rather than a diagnosis
Syndromic classification	No standardized syndromic classification	“MB syndrome” represents descriptive, non-standardized usage
International Classification of Diseases	ICD-10 code R06.5 (MB)	Classified under symptoms and signs involving the respiratory system
Diagnostic and Statistical Manual of Mental Disorders	Not included	No psychiatric or behavioral disorder classification

Neurocognitive and Quality-of-Life Implications
MB has significant neurocognitive and psychosocial impacts, affecting sleep quality, oxygenation, and daily functioning, particularly in pediatric populations [40-42]. It can lead to attention deficits, reduced academic performance, and emotional dysregulation, mimicking attention-related disorders [41]. Chronic MB may influence neurodevelopment, contributing to longer-term cognitive and emotional challenges [42,43]. Additionally, oral symptoms and facial changes can affect self-confidence and social interactions [44,45].

Clinical Dental Assessment of MB
A comprehensive evaluation of nasal patency is crucial in dental patients with suspected MB, as nasal obstruction is a primary cause of MB [46,47]. Dentists may be the first healthcare professionals to encounter mouth-breathing children and can play a key role in early identification. A structured assessment includes patient history, observation of resting breathing patterns, and evaluation for signs of upper airway obstruction, such as tonsillar enlargement.
Inspection of the external nares, lip competence, tongue posture, dental malocclusion, and facial development can provide indirect indicators of compromised airflow [47-49]. However, reliance on subjective reporting or craniofacial features alone is insufficient for diagnosis and does not confirm underlying nasal obstruction.
Chair-side screening tests-including the mirror (Glatzel) Fig. 1, lip seal, and water retention tests-are widely used to provide preliminary insights into nasal patency and help differentiate habitual from obstructive MB [48-50]. However, these methods remain semi-quantitative and technique-sensitive, limiting diagnostic reliability. Reported usage patterns vary across clinical settings, reflecting a lack of standardization [51].
No single test is definitive; therefore, combining multiple assessments is recommended to improve diagnostic confidence [5,40]. Comprehensive evaluation often requires a stepwise, multidisciplinary approach incorporating clinical examination, repeated observations, and, when indicated, objective measures of nasal and airway function in collaboration with otolaryngology and sleep medicine specialists [50-53].

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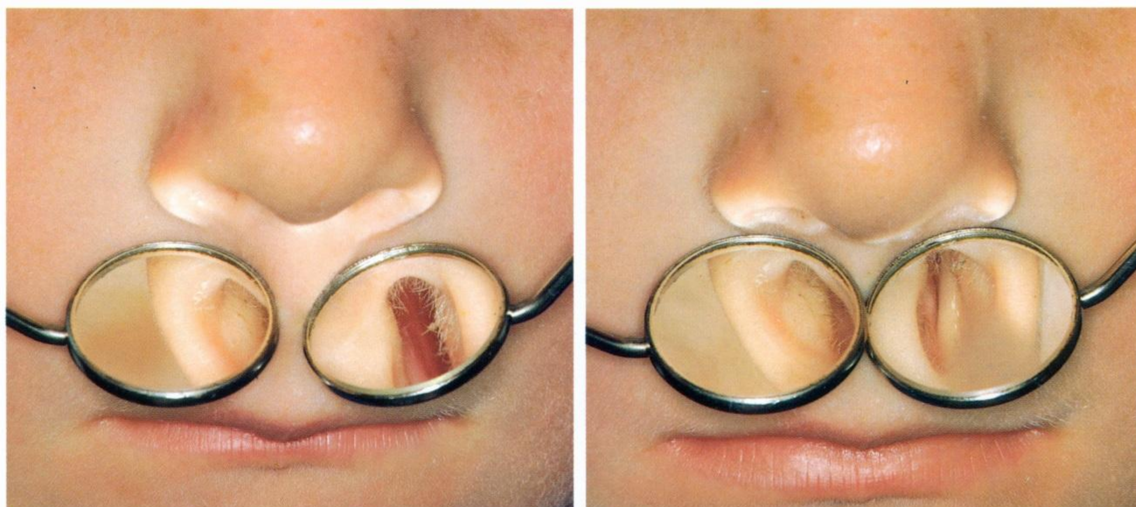

Fig. 1. Mirror test. A mirror is held beneath the nostrils to assess nasal airflow. In nasal breathing, the mirror fogs due to condensation during expiration, as shown on the right. Adapted with permission from the publisher. From: Rakosi T, Jonas I, Graber TM. *Color Atlas of Dental Medicine: Orthodontic Diagnosis.* Stuttgart: Thieme; 1994. pp. 163–164.

Table 2. Screening and Diagnostic Methods for Mouth Breathing

At-Home and Visual Screening Methods*	Diagnostic Tools for Mouth Breathing Assessment
Mirror test: nasal airflow causes fogging under the nostrils **Lip seal / water-holding test:** inability to maintain lip closure suggests an oral breathing pattern **Paper tape (awake only):** assesses ability to maintain lip seal (screening only) **"Butterfly" cotton test:** nasal airflow moves fibers downward; absent/altered movement suggests oral breathing **Hand-over-mouth test (sleep observation):** brief occlusion may help differentiate habitual vs. obstructive patterns **Video observation (sleep):** detects open-mouth posture during sleep and records snoring **Symptom check:** dry mouth, chapped lips, halitosis, fatigue, snoring, gingival inflammation	**Rhinometry** Acoustic rhinometry: sound waves to assess nasal cavity geometry Rhinomanometry: measures nasal airflow and resistance — Quantifies nasal obstruction (e.g., septal deviation, turbinate hypertrophy) **Cone Beam CT (CBCT)** — 3D evaluation of nasal cavity, sinuses, and upper airway anatomy **3D Facial Scanning** — Assesses craniofacial morphology (e.g., adenoid facies) **Virtual Endoscopy** — 3D airway visualization from CT/MRI datasets **MRI** — Detailed soft tissue assessment (reserved for complex cases, especially pediatric) **Lateral Cephalometric Radiography** — Evaluates skeletal relationships and airway dimensions (orthodontic use)

**At-home methods are screening tools only and require clinical confirmation.*

Management Considerations

The management of MB requires a comprehensive, etiology-driven, and interdisciplinary approach aimed at restoring nasal respiration, correcting functional imbalances, and preventing long-term consequences. As MB is typically a symptom rather than a primary disease entity, effective management depends on accurate identification and treatment of underlying causes [50,54].

Adequate airway patency is a prerequisite for successful intervention, as insufficient nasal permeability limits the effectiveness of breathing retraining. Structural or functional nasal obstruction should therefore be excluded before recommending mouth-closure adjuncts, such as taping or supportive devices [46,55]. Adjunctive strategies-including optimization of nasal hygiene, allergen avoidance, and the use of nasal dilators-may further support functional improvement [54,55].

Orofacial myofunctional therapy plays a central role in neuromuscular re-education, promoting nasal breathing and improving orofacial function. These interventions are particularly effective in pediatric populations, although benefits may extend to motivated adolescents and adults [50,56].

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In patients with dentoskeletal alterations, orthodontic intervention may be required to correct malocclusion and guide craniofacial growth. Functional appliances may also contribute to improved mandibular positioning and airway stability [57,58].
Given the chronic and multifactorial nature of MB, longitudinal monitoring is essential to ensure treatment efficacy and minimize relapse. Follow-up should include assessment of nasal patency, breathing patterns, craniofacial development, and patient adherence [59].

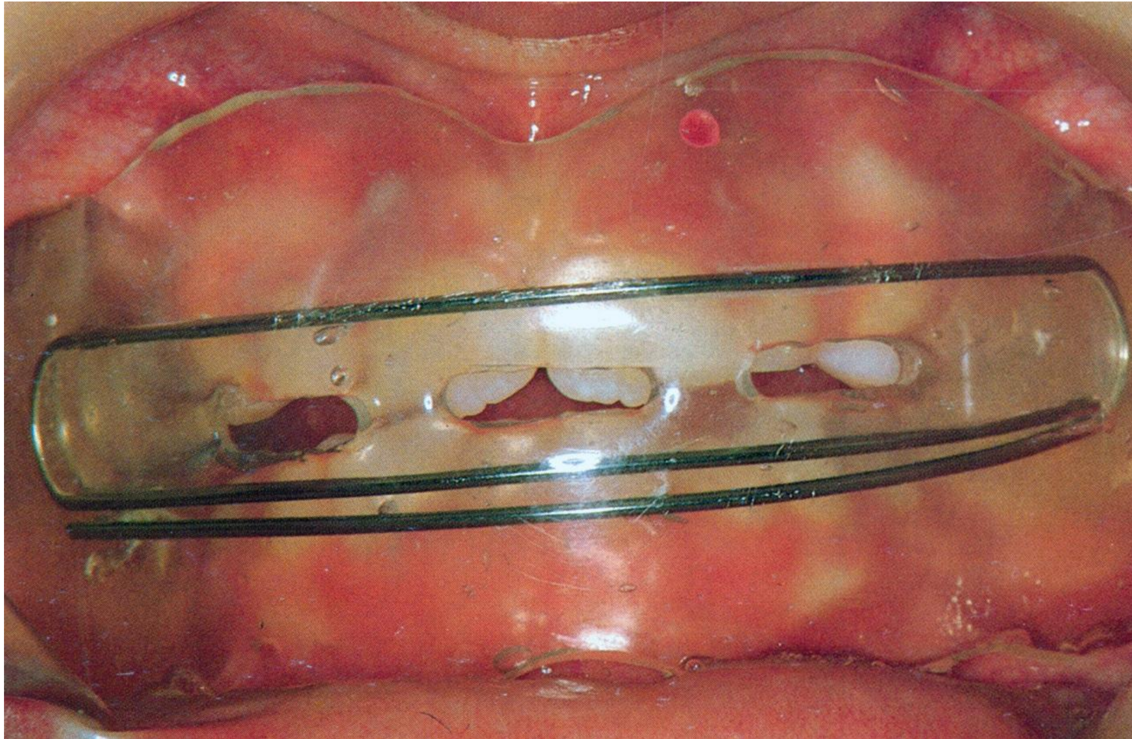

Fig. 2. Modification of habitual mouth breathing. A custom-made perforated oral screen is positioned within the oral vestibule. The perforations are progressively occluded to encourage transition from mouth breathing to nasal breathing. Adapted from Rakosi T, Jonas I, Graber TM. *Color Atlas of Dental Medicine: Orthodontic Diagnosis.* Stuttgart: Thieme; 1994. pp. 163–164.

Patient and Family Engagement

Effective management of MB requires active engagement of both patients and their families, particularly in pediatric populations where behavioral patterns and adherence are caregiver-dependent [59]. Structured education on the importance of nasal breathing and the consequences of untreated MB is essential. Clinicians should clearly explain underlying causes and the rationale for each component of treatment. Visual aids and age-appropriate explanations can enhance understanding [54]. Consistency at home plays a central role. Adherence to prescribed therapies, including medications, appliances, and myofunctional exercises, is critical. Regular follow-up reinforces motivation and allows for timely adjustments [54].

Emerging Technologies for Facilitating the Transition from Mouth to Nasal Breathing

Recent advances in behavioral rehabilitation and digital health have introduced tools that support the transition from mouth to nasal breathing by targeting neuromuscular retraining and habit formation [58,59]. Device-based interventions include intraoral appliances designed to guide oral posture and discourage mouth airflow. These devices promote nasal breathing through passive positioning and sensory feedback mechanisms [60-62]. Biofeedback and wearable systems enable real-time monitoring of breathing parameters, translating physiological signals into cues that support self-regulation [60,63-65].
Digital and AI-driven tools further reinforce behavioral change through continuous feedback and adaptive responses, particularly in pediatric populations [64,65]. Although promising, these technologies remain in early or experimental stages, and further research is required to establish long-term efficacy and optimal clinical integration [50,56].

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Discussion

Mouth breathing is increasingly conceptualized as a multifactorial functional condition arising from the interaction of structural airway factors, neuromuscular regulation, and behavioral adaptation. Rather than representing a discrete entity, it exists along a clinical continuum ranging from transient compensatory responses to persistent, maladaptive patterns with potential systemic and developmental consequences. Accordingly, MB is variably described as a clinical sign or compensatory response [2,6], as well as a learned behavior or functional disorder [14,66]. Functional determinants of airway pattern reflect the dynamic interplay of neuromuscular control, behavioral adaptation, and posture, supporting the concept of MB as a continuum often initiated by structural factors and maintained through neuromuscular adaptation [48,58]. Despite increasing recognition, significant gaps remain in its definition, pathophysiology, and management. Its relationship with craniofacial development is likely bidirectional rather than strictly causal, supporting multifactorial models over deterministic frameworks [34,36].

Systemic regulatory mechanisms, including nitric oxide signaling and inflammatory pathways, are increasingly recognized as contributing factors, although their precise clinical significance remains incompletely defined [4,5]. In addition, the maintenance of adequate hydration within the upper airway mucosa appears to play a critical role, particularly in the context of contemporary respiratory challenges associated with exposure to polluted and low-humidity air. Emerging evidence suggests that airway surface dehydration may promote inflammatory responses and neural activation through osmotic stress on the airway lining mucus, thereby exacerbating respiratory dysfunction [6]. It has also been hypothesized to influence neuroendocrine regulation, including the hypothalamic-pituitary-adrenal axis, though evidence remains limited [30].

Neurocognitive associations are well documented but appear largely mediated by sleep-disordered breathing rather than MB per se [12,41,42]. Diagnostic limitations persist due to reliance on subjective and semi-quantitative methods [49,50], which may contribute to variability in reported prevalence and clinical interpretation. Standardized protocols and objective assessment tools are therefore needed. Although emerging evidence indicates that circadian regulation influences respiratory patterns, neuroendocrine activity, and tissue homeostasis, its direct role in the pathogenesis of mouth breathing remains incompletely defined. Circadian rhythms are closely linked to hypothalamic-pituitary-adrenal axis function and sleep architecture, both of which are frequently altered in individuals with sleep-disordered breathing [1,43]. In pediatric populations, circadian disruption may therefore act as a modifying factor rather than a primary cause, potentially interacting with intermittent hypoxia, airway obstruction, and neuromuscular adaptation, which may influence breathing behavior and potentially contribute to craniofacial developmental patterns [67]. These interactions suggest that temporal dysregulation may contribute to the persistence of maladaptive breathing patterns, reinforcing the concept of MB as a multifactorial condition shaped by both structural and systemic influences.

MB may also be conceptualized within a triad linking respiratory patterns, cervical dysfunction, and temporomandibular disorders. Forward head posture and altered neuromuscular coordination contribute to dynamic, self-reinforcing interactions between airway function and the musculoskeletal system [2,32,33]. Overall, MB should be viewed not as an isolated condition but as part of an integrated, interacting system involving airway biology, neuromuscular adaptation, and craniofacial growth [68]. Management remains interdisciplinary but heterogeneous, with variable evidence supporting individual interventions, including myofunctional therapy, orthodontic interventions, and airway-targeted treatments [50,52,54,69]. Personalized, patient-centered approaches are therefore recommended. In Libya, limited epidemiological and functional data underscore the need for region-specific research and improved clinical awareness. Future studies integrating standardized diagnostic frameworks with longitudinal and context-specific approaches will be essential to advance understanding and optimize clinical management.

Conclusion

This narrative review positions mouth breathing (MB) as a clinically modifiable functional disorder with significant respiratory, musculoskeletal, and developmental consequences affecting the craniofacial complex, cervical region, and temporomandibular joint. A critical epidemiological gap persists in Libya, limiting understanding of its prevalence, risk factors, and long-term outcomes. Addressing this gap through standardized diagnostic criteria, longitudinal research, and context-specific studies is essential to advance evidence-based, contextually relevant clinical practice. Reframing MB as a clinically significant condition, particularly in underrepresented settings, may enhance early detection, support interdisciplinary management, and ultimately improve patient outcomes.

Conflict of interest. Nil

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