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The impact of malocclusion and temporomandibular disorders on athletic performance and postural control - a narrative review

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Abstract

Background: The stomatognathic system, which includes the occlusion and the temporomandibular joints (TMJ), is closely linked to overall body posture through neurological and biomechanical pathways. Consequently, malocclusions and temporomandibular disorders

(TMD) can cause compensatory muscle tension and affect postural control. This raises the question of whether, in sports-where optimal balance and neuromuscular coordination are essential-these dysfunctions could potentially impair athletes' performance.

Aim: The purpose of this review is to analyze and summarize the current scientific evidence regarding the impact of malocclusion and temporomandibular joint disorders on body posture control and athletic performance.

Material and methods: A narrative review was conducted using 24 scientific publications from the PubMed and the Quality in Sport journal database.

Results: Neurophysiological mechanisms, such as the trigeminal-cervical reflex, functionally link the stomatognathic system to cervical muscle tone and body posture. Malocclusions and temporomandibular joint (TMJ) disorders are often associated with increased postural instability and a shift in the center of pressure (COP), especially under challenging sensory conditions. However, in trained athletes, natural static malocclusions do not directly affect maximal aerobic capacity or muscle strength. It has been reported that custom-fitted bite splints and mouthguards, by altering jaw position, can increase maximum isometric strength, explosive strength, and trunk stability by strengthening the neuromuscular system. However, research findings are often inconsistent, and opinions in the literature are divided.

Conclusions: Malocclusions and temporomandibular joint disorders affect body posture and balance control, which are based on complex neurophysiological relationships. However, research findings to date remain inconclusive and show a strong dependence on external measurement conditions. Further studies are needed to clarify.

Key words: malocclusion, temporomandibular disorders (TMD), postural control, athletic performance, stomatognathic system, postural balance

1. Introduction

In modern medicine and sports biomechanics, the masticatory system is no longer treated as an isolated anatomical unit, but rather as an integral part of the kinematic chain and the body's postural control system (Ioniță et al., 2023; Leroux et al., 2018; Minervini et al., 2023). The stomatognathic and craniocervical functional systems form an interdependent structure connected by neuromuscular and ligamentous links (Fiorillo, 2020; Harhoff et al., 2024; Minervini et al., 2023).

The neurophysiological basis of this integration rests on a complex network of afferent connections (Hecht et al., 2025; Marchesi et al., 2024; Marchili et al., 2016). Sensory and

nociceptive information from receptors in the periodontium, masticatory muscles, and temporomandibular joint is transmitted via branches of the trigeminal nerve to the spinal tract and the trigeminal-cervical nucleus in the brainstem (Hecht et al., 2025; Kołodziej-Sieradz et al., 2026; Marchesi et al., 2024; Marchili et al., 2016). Since this area is directly adjacent to the centers controlling motor function of the cervical spine and the vestibular system, disturbances in occlusion or the temporomandibular joint can cause reflex changes in muscle tone that cascade down the postural chain (Hecht et al., 2025; Herzog et al., 2022; Kołodziej-Sieradz et al., 2026; Marchili et al., 2016). In addition, myofascial bands and the richly vascularized and innervated deep fascia play a significant role, as they transmit mechanical stress from the masticatory system to peripheral body segments (Harhoff et al., 2024; Kołodziej-Sieradz et al., 2026; Minervini et al., 2023). Maintaining stable body posture under static and dynamic conditions requires precise integration of stimuli from the three main sensory systems: the visual, vestibular, and somatosensory (including proprioceptive) systems (Carini et al., 2017; Ioniță et al., 2023; Julià-Sánchez et al., 2020; Leroux et al., 2018; Nowak et al., 2023). The body's center of pressure (CoP) undergoes constant micro-oscillations, and the quality of postural control determines the precision of motor task execution, coordination, and injury prevention in athletes (Ioniță et al., 2023; Leroux et al., 2018; Nowak et al., 2023).

The presence of occlusal abnormalities and temporomandibular disorders (TMD) can lead to an abnormal distribution of postural tension (Deshmukh et al., 2024; Harhoff et al., 2024; Minervini et al., 2023; Nowak et al., 2023). In athletes, these dysfunctions may manifest as asymmetry in foot pressure on the ground, an increased range of CoP deviations, and reduced motor coordination and dexterity, particularly in disciplines requiring high precision, such as shooting, gymnastics, or combat sports (Dias et al., 2018; Didier et al., 2021; Kołodziej-Sieradz et al., 2026; Nowak et al., 2023; Ohlendorf et al., 2021).

Research Objective:

The main objective of this narrative review is to synthesize current scientific evidence regarding the impact of malocclusion and temporomandibular disorders on postural control and athletic performance, and to evaluate the underlying mechanisms.

Research Problems:

1. Do malocclusions and temporomandibular disorders significantly alter postural control and balance in athletes?

2. Do occlusal splints and bite adjustments provide measurable ergogenic benefits for athletic performance and muscle strength?

Research Hypotheses:

1. Malocclusions and temporomandibular joint disorders (TMD) negatively affect static and dynamic postural control by altering the distribution of the center of pressure, which results in poorer performance among athletes.
2. Individually tailored interventions to correct occlusal disorders improve neuromuscular coordination and athletic performance by enhancing nervous system activity.

2. Research materials and methods

A comprehensive literature review was conducted to identify relevant studies on the relationship between malocclusion, temporomandibular joint disorders (TMD), posture control, and athletic performance. The main databases used for the search were PubMed and the archive of the journal Quality in Sport. The search strategy combined keywords such as "malocclusion," "temporomandibular joint disorders," "TMD," "postural control," "postural balance," and "athletic performance." A total of 24 peer-reviewed articles that met the study criteria were selected and included in this review. Inclusion criteria included studies in English focusing on human subjects, athletes, or neuromuscular assessments related to the stomatognathic system. Articles for which the full text was not available or that did not address the above topics were excluded.

2.1 AI.

During the preparation of this article, artificial intelligence technologies were used solely in a supporting role and operated under full human supervision. They assisted in selecting the structure and synthesizing reference materials to facilitate the organization of the literature. In addition, artificial intelligence was used to refine scientific terminology in English, improve grammatical accuracy, and ensure stylistic compliance with professional standards for scientific publications.

The use of artificial intelligence was limited to text processing and linguistic refinement. All key data interpretations, methodological synthesis, final conclusions, and scientific assessments were conducted and verified independently by the authors, who bear full responsibility for the entire content of this article.

3. Research results

A structured methodological synthesis of selected primary studies investigating the relationship between stomatognathic parameters, postural control, and physical performance is presented in Table 1.

Table 1

Methodological Synthesis and Quantitative Findings of Selected Primary Studies

Author & Year	Study Population (N)	Methodology & Equipment	Evaluated Variable / Intervention	Quantitative Key Findings (p-value)
Leroux et al. (2018)	7 elite rowers	Force platform, sEMG, Dyno leg-press	4 mm lateral mandibular deflection	Paravertebral asymmetry in 85.7% (p = .025); **17.7% drop in power** (p = .030).
Dias et al. (2018)	13 elite pistol shooters	Force platform (CoP), sEMG (upper limb), SIUS target	Custom TMJ repositioning splint vs. Placebo	**No significant difference** in CoP sway, sEMG, or shooting score (p > .05).
Maurer et al. (2018)	23 active adults	Contact mat (jumps), isometric force transducers	Centric vs. Myocentric (DPS) vs. Neutral splints	**3% to 12% increase** in jump height and max isometric strength (p < .05).
Ohlendorf et al. (2021)	12 elite Taekwondo athletes	3D spine rasterstereography, sonoSens ROM	Custom vs. Boil-and-bite mouthguards	Minor spinal angular deviations **< 1° (< 5%)**, clinically

Author & Year	Study Population (N)	Methodology & Equipment	Evaluated Variable / Intervention	Quantitative Key Findings (p-value)
				non-significant.
Herzog et al. (2022)	38 recreational athletes	Capacitive pressure plate (CoP), ultrasonic ROM	Custom centric occlusal splint vs. Habitual bite	**28.2%-31.5% reduction** in CoP sway area ($p < .01$); increased cervical ROM.
Nowak et al. (2023)	90 young adults (n = 30/class)	Computerized baropodometry, CoP tracking	Angle Class I vs. Class II vs. Class III malocclusions	**Class II:** forward CoP shift (66.7% of subjects) **Class III:** backward CoP shift and higher sway ($p < 0.05$).
Harhoff et al. (2024)	30 subjects (15 TMD / 15 controls)	DIERS 4D 3D rasterstereography, baropodometry	Manual therapy combined with occlusal splints	Significant acute correction in pelvic tilt ($p = 0.012$) and spinal curves in TMD patients.
Hecht et al. (2025)	30 competitive soccer players	Isokinetic dynamometer (Biodex), T-Scan	Simulated unilateral 3 mm occlusal interference	**Significant decrease** in peak torque, work, and knee extensor power ($p < .01$).

3.1. Neurophysiological and biomechanical mechanisms linking the stomatognathic system to postural control and balance

The stomatognathic system interacts closely with the motor system through three main mechanisms (Carini et al., 2017; Ioniță et al., 2023):

Trigeminal-cervical reflex: Impulses from periodontal and temporomandibular joint receptors travel via the trigeminal nerve (CN V) to the brainstem, where they converge with neurons in the upper cervical region (C1–C3) (Kołodziej-Sieradz et al., 2026). This convergence means that occlusal irritation or TMJ pain reflexively alters the tension in the neck muscles (e.g., the trapezius or sternocleidomastoid), forcing a compensatory head posture (e.g., protraction) and resulting in a shift in the body's center of pressure (CoP) (Minervini et al., 2023; Nowak et al., 2023).

Myofascial Tracts: The mandible is biomechanically connected to the hyoid bone, the thoracic cage, and the shoulder girdle (Didier et al., 2021). Malocclusion or unilateral tension in the masseter muscles generates kinetic stresses that travel along the deep neck fascia down the spine, causing trunk rotation, pelvic tilt, and asymmetry in foot pressure (Deshmukh et al., 2024; Harhoff et al., 2024).

CNS Integration (including the CAP effect): The masticatory system sends strong proprioceptive signals to the central nervous system, interacting with the visual system (influencing gaze fixation) and the vestibular system (Ioniță et al., 2023; Marchesi et al., 2024). Furthermore, conscious or reflexive clenching of the teeth activates the concurrent activation potentiation (CAP) phenomenon, lowering the excitability threshold of motor neurons in the spinal cord, which facilitates trunk muscle recruitment and postural stabilization (Hecht et al., 2025; Siatkowska et al., 2026).

3.2 Impact of Malocclusion and Temporomandibular Disorders on Postural Control and Balance

To investigate how the jaw affects body posture, researchers use specialized equipment such as force platforms and 3D body scanners. These tools measure body sway, foot pressure

distribution, spinal curves, and dynamic balance (Herzog et al., 2022; Ioniță et al., 2023; Nowak et al., 2023).

The scientific literature shows clear links between specific bite problems and posture:
- Angle Class II (Retrognathia / Overbite): Individuals with this jaw alignment tend to shift their body weight forward onto the front part of the foot (forefoot). To keep airways open, they often compensate with a forward head posture, which results in poorer overall body stability and increased body sway (Nowak et al., 2023; Siatkowska et al., 2026).
- Angle Class III (Prognathism / Underbite): In contrast, these individuals tend to shift their center of gravity backward toward their heels, showing increased side-to-side body movement during single-leg balance tests (Nowak et al., 2023).
- Temporomandibular Disorders (TMD): Patients suffering from TMD often present with increased body sway, spinal curvatures, and pelvic imbalances. Interestingly, treatments like occlusal splints or physical therapy have been shown to help correct these postural asymmetries (Harhoff et al., 2024; Minervini et al., 2023).
- Bite Asymmetries: If chewing forces are stronger on one side of the mouth, the body often creates a "crossed" compensation, shifting weight toward the opposite side to maintain balance (Deshmukh et al., 2024). Even a small, artificial shift in the jaw can instantly trigger muscle tension imbalances along the spine (Leroux et al., 2018).

3.3. Influence of Occlusal Splints, Mouthguards, and Jaw Alignment on Athletic Performance

Recent studies distinguishing long-standing structural malocclusions from sudden changes in occlusion indicate that static, uncorrected malocclusions (such as Class II or III according to Angle's classification) do not cause a direct, linear decrease in maximum oxygen uptake or peak force in well-trained athletes (Siatkowska et al., 2026). The body effectively develops reflex compensatory mechanisms-such as switching to mouth breathing, increased respiratory rate, and adjustments to the posture of the cervical spine (e.g., forward head posture [FHP]) - to mitigate a potential decline in performance during standard exercise tests (Siatkowska et al., 2026).

Chronic adaptation to malocclusions results in a metabolic burden. The narrowed upper airway dimensions in Class II malocclusions require constant mouth breathing, which eliminates the

benefits of nitric oxide (NO) in the paranasal sinuses, increases airflow resistance, and accelerates respiratory muscle fatigue during prolonged endurance exercise (Siatkowska et al., 2026).

In contrast to chronic malocclusions, the acute introduction of an artificial bite interference (e.g., a 1-4 mm silicone wafer or mandibular lateralization) triggers an immediate decline in strength and dynamic performance parameters (Hecht et al., 2025; Leroux et al., 2018). Leroux et al. (2018) demonstrated in elite rowers that a 4 mm artificial lateral mandibular deflection provoked paravertebral muscle contraction asymmetry in 85.7% of subjects and a 17.7% drop in muscular power during leg-press ergometer trials ($p = 0.030$). Similarly, Hecht et al. (2025), in a randomized isokinetic study on soccer players, proved that simulated occlusal interferences significantly decrease maximum torque, total work, and power output in knee extensors and flexors compared to habitual occlusion.

3.4. The Effects of Occlusal Splints and Mouthguards on Isometric Strength, Power, and Core Stabilization

Increases in strength, power, and stability via occlusal splints: Maurer et al. (2018) showed that customized jaw-repositioning splints in centric or myocentric position (Dental Power Splint – DPS) improve jump performance (Squat Jump, Countermovement Jump, Drop Jump) and increase maximal isometric strength in trunk extension and leg-press by 3.8% to 12%. Herzog et al. (2022) proved that wearing a customized centric splint reduces Center of Pressure (CoP) sway area by 28.2%–31.5% during single- and double-leg stances while increasing cervical spine range of motion (ROM). Furthermore, Maurer et al. (2015) reported improved running gait symmetry when utilizing individual occlusal splints.

Biomechanical comparison: Custom-made vs. "boil-and-bite" mouthguards:

Custom-made guards: Fabricated from dental impressions/digital scans in centric relation. They ensure ideal retention without requiring active clenching, effectively absorb impact energy, do not hinder breathing or speech, and safely facilitate the CAP effect (Pawlak et al., 2026; Siatkowska et al., 2026).

Boil-and-bite (B&B) guards: Lack precise occlusal adaptation, forcing athletes to constantly and actively bite down to retain them (Pawlak et al., 2026). This induces iatrogenic hypertonus and masticatory muscle fatigue, reduces airway patency, and generates discomfort in the temporomandibular joints (Pawlak et al., 2026).

3.5. Contradictions in the literature and the lack of results in some studies

Despite the benefits described in biomechanical studies, a significant portion of the literature points to the absence of an ergogenic effect in specific sports tasks:

No effect on highly precise and dynamic sports:

- Sport shooting: Dias et al. (2018), in a study of national team members in pistol shooting, demonstrated that changing the position of the mandible using an occlusal splint did not significantly affect CoP deviations, electromyographic (sEMG) activity of the aiming upper limb muscles, or the accuracy and concentration of shots. Advanced athletes rely on established neuromuscular patterns that are resistant to short-term modifications in occlusion (Dias et al., 2018).
- Taekwondo and combat sports: Ohlendorf et al. (2021), in a study of elite Taekwondo athletes, demonstrated that although protective gear induces minor angular adaptations of the spine during attack-defense sequences, these deviations do not exceed 5% / 1°, are clinically insignificant, and do not affect overall movement dynamics or performance.

Conclusions from literature reviews:
Systematic reviews indicate that while the evidence for the effectiveness of mouthguards in preventing orofacial injuries is unequivocal and very strong, the evidence for their ergogenic effects (improvements in strength, speed, or endurance) is characterized by significant methodological heterogeneity and individual variability (Hecht et al., 2025; Pawlak et al., 2026; Siatkowska et al., 2026).

Main reasons for discrepancies in study results:
The participants' level of training: Elite athletes possess highly developed postural control and stable movement patterns, making them less sensitive to occlusion interventions than recreational exercisers (Dias et al., 2018; Ohlendorf et al., 2021).

Nature of the exercise test: The benefits of using splints are primarily evident in isometric tests and standing jumps, whereas they are difficult to observe in isokinetic exercises, sprints, or complex technical disciplines (Hecht et al., 2025; Maurer et al., 2018).

Differences in testing protocols: The lack of standardized procedures for recording centric relations during splint use makes it difficult to compare results across different research centers (Herzog et al., 2022; Pawlak et al., 2026).

4. Discussion

4.1. Interpretation of Findings and Discrepancies

The synthesized evidence demonstrates that while neurophysiological links (trigemino-cervical reflex, myofascial continuity) exist between the stomatognathic system and postural control, performance impact varies widely across literature due to key factors:

- Athletic Level: Elite athletes possess consolidated motor patterns resilient to minor occlusal changes (Dias et al., 2018; Leroux et al., 2018), whereas untrained individuals show higher neuromuscular sensitivity (Hecht et al., 2025; Maurer et al., 2018).
- Testing Demand: Postural and ergogenic shifts manifest predominantly during complex or unstable tasks (e.g., fatigue, single-leg stance, closed eyes) rather than simple static balance (Didier et al., 2021; Nowak et al., 2023).
- Appliance Quality: Custom-made splints in centric relation optimize joint loading and strength responses, whereas over-the-counter "boil-and-bite" guards cause masseter hypertonus and fatigue (Ohlendorf et al., 2021; Pawlak et al., 2026).
- Task Specificity: Concurrent Activation Potentiation (CAP) via tooth clenching aids maximal isometric force and vertical jump explosive power (Siatkowska et al., 2026), but offers negligible benefits in fine-motor or dynamic agility tasks (Dias et al., 2018).

4.2. Practical Guidelines for Interdisciplinary Care

An interdisciplinary approach is essential for optimizing care for athletes:

- Sports dentistry and orthodontics: Custom-fitted appliances in the centric relation should replace standard “boil-and-bite” mouthguards to protect tissues and prevent iatrogenic muscle strain (Pawlak et al., 2026). Mandibular advancement may also improve airway patency during intense exercise (Siatkowska et al., 2026). Screening for temporomandibular joint disorders

(TMD) must be based on DC/TMD criteria, supported by CBCT, MRI, or POCUS imaging (Kołodziej-Sieradz et al., 2026).

- Physical Therapy: Screening of the stomatognathic system is recommended for athletes with chronic cervical spine strain or postural asymmetry, as temporomandibular disorders (TMD) affect the paraspinal muscles and plantar pressure (Harhoff et al., 2024; Nowak et al., 2023). Manual therapy of the temporomandibular joint (TMJ) allows for immediate postural correction, but to achieve long-term benefits, it must be combined with stabilization of the trunk muscles (Harhoff et al., 2024).
- Training: Chronic malocclusions are compensated for and do not negatively affect baseline VO_2max or strength values (Siatkowska et al., 2026). However, acute artificial disruptions or poorly fitted mouthguards cause muscular asymmetry and immediate

4.3. Methodological Limitations

Interpretation of current evidence is constrained by several limitations: small athletic sample sizes ($N < 15$) (Dias et al., 2018), cross-sectional single-session designs lacking longitudinal tracking (Harhoff et al., 2024), participant blinding challenges (Hecht et al., 2025), artificial occlusal interferences that fail to mirror natural malocclusion adaptation (Siatkowska et al., 2026), and diagnostic heterogeneity across measuring devices (Minervini et al., 2023).

4.4. Recommendations Summary

Practical guidelines and future research directions synthesized from the review are presented in Table 2.

Table 2

Practical Recommendations and Future Research Framework

Domain	Practical & Clinical Guidelines	Key Future Research Directions
Sports Dentistry	• Mandate custom-made splints/mouthguards in centric	Conduct long-term RCTs examining multi-week motor

Domain	Practical & Clinical Guidelines	Key Future Research Directions
	relation; avoid "boil-and-bite" guards. • Apply DC/TMD diagnostic standards with CBCT, MRI, or POCUS imaging.	adaptations to custom appliances in elite cohorts.
Physiotherapy	• Screen stomatognathic function in athletes with recurrent neck strain or pelvic asymmetry. • Combine TMJ/cervical manual therapy with core stabilization for sustained postural balance.	Evaluate sport-specific dynamic movements (sprinting, agility) using dynamic sEMG and 3D kinematics.
Coaching	• Prevent ill-fitting mouthguards that trigger muscle asymmetry and power losses (up to 17.7%). • Treat occlusal devices as protective/stabilizing tools rather than general performance boosters.	Analyze bioenergetic and respiratory costs of Class II malocclusions during prolonged fatigue.

5. Conclusions

The synthesized evidence demonstrates that chronic malocclusions do not directly impair baseline aerobic capacity (VO_2 max) or maximal strength in trained athletes, as the

neuromuscular system establishes effective compensatory mechanisms. In contrast, acute artificial occlusal interferences provoke immediate power losses and muscular asymmetries.

Custom-made intraoral appliances in centric relation provide essential orofacial protection and can yield moderate biomechanical benefits, such as enhanced postural control and CAP-driven isometric force increases. These distinctively outperform generic "boil-and-bite" guards, which risk inducing masseter hypertonus.

Ultimately, due to the complex neurofascial linkages between the stomatognathic and locomotor systems, an interdisciplinary care model integrating sports dentistry, physiotherapy, and coaching is essential. Future investigations should prioritize longitudinal trials utilizing standardized DC/TMD diagnostics in elite cohorts.

Disclosure

Author Contributions

Conceptualization: [JP], [AK], [MD], [AS], [MP], [AB], [JM], [MW], [RD], [NK]
Methodology: [JP], [AK], [MD], [AS], [MP], [AB], [JM], [MW], [RD], [NK]
Software: Not applicable.
Validation: Not applicable.
Formal analysis: Not applicable.
Investigation: [JP], [AK], [MD], [AS], [MP], [AB], [JM], [MW], [RD], [NK]
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Conflicts of Interest

The authors declare no conflict of interest.

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