International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(Research Article)

The Effect of Chronic Physical Exercise with Different Intensities on the Incidence of Temporomandibular Disorder in Amateur Athletes

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International Journal of Science and Research Archive, 2025, 17(01), 1296–1303

Publication history: Received on 15 September 2025; revised on 25 October 2025; accepted on 27 October 2025

Article DOI: https://doi.org/10.30574/ijsra.2025.17.1.2894

Abstract

Background: Temporomandibular disorder (TMD) is a multifactorial dysfunction of the masticatory system, with physical stress contributing through inflammation, microtrauma, and joint damage. While athletes show higher TMD prevalence due to physical load, evidence on chronic exercise intensity in amateur athletes remains scarce.Understanding the relationship between physical activity intensity and musculoskeletal health enables this study to contribute to achieving good health and well-being through the prevention of TMD.

Method: Participants were 64 male amateur athletes selected through purposive sampling. Physical activity was assessed using the Global Physical Activity Questionnaire (GPAQ), while temporomandibular disorder (TMD) was evaluated with the Diagnostic Criteria for TMD (DC/TMD). The data were analyzed using the Chi-Square test ($p < 0.05$) in SPSS version 29. When the p-value was below 0.05 (p = 0.014), it indicated a statistically significant association between physical activity intensity and TMD incidence.

Result: A total of 64 participants were included in the study, comprising 4 individuals (6.3%) who engaged in low-intensity physical activity, 27 individuals (42.2%) in moderate-intensity activity, and 33 individuals (51.6%) in high-intensity activity. Among them, 40 participants exhibited symptoms of temporomandibular disorder (TMD), while 24 (37.5%) did not. The highest prevalence of TMD was observed in the high-intensity group (40.6%) with $p = 0.014$.

Conclusion: TMD occurred due to increased stress levels caused by chronic physical exercise. High-intensity chronic physical exercise has the potential to cause TMD in amateur athletes.

Keywords: Temporomandibular Disorder; Physical Stress; Chronic Physical Exercise; Stress Level; Amateur Athletes

1. Introduction

Temporomandibular disorder (TMD) is a musculoskeletal condition that affects the human masticatory system and can be identified through symptoms and clinical signs reflecting an underlying pathological process [1]. The occurrence of TMD is attributed to multiple factors, including age, sex, hormonal imbalances, trauma, stress, and systemic diseases [2]. Despite its complex and multifactorial etiology, TMD remains a significant public health issue, affecting approximately 6%-12% of the population, with a higher prevalence in women and individuals aged 20 to 40 years [3,4]. Women are three times more likely to develop TMD than men, primarily due to hormonal fluctuations, particularly in estrogen levels, which contribute to TMD pathogenesis [5].

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Besides sex, stress is recognized as a major risk factor for the development of temporomandibular disorders (TMD) in both men and women. The biological mechanisms underlying this relationship include dysregulation of the hypothalamic–pituitary–adrenal (HPA) axis, increased cortisol secretion, and hyperactivity of the masticatory muscles, which together contribute to impaired pain modulation and musculoskeletal imbalance [6,7]. Stress is generally classified into psychological and physical categories, each exerting distinct but sometimes overlapping effects on systemic homeostasis [8]. Psychological stress arises from emotional or cognitive stimuli processed in the central nervous system, whereas physical stress originates from somatic disturbances such as pain, thermal changes, and hypovolemia that directly challenge physiological equilibrium [8,9].

In the context of TMD, physical stress is particularly important due to its direct influence on neuromuscular and joint function [9]. Persistent exposure to physical stressors may increase muscle tension, alter jaw biomechanics, and exacerbate joint strain, thereby facilitating the onset or progression of TMD [10]. The impact of physical stress is determined by both its intensity and duration, commonly categorized as mild (≤50% of maximal capacity), moderate (50–70%), and high (≥70%) [8]. These gradations reflect the cumulative burden that physical challenges impose on the stomatognathic system, underscoring the role of sustained physical stress in compromising mandibular stability and increasing susceptibility to temporomandibular dysfunction [10].

Based on duration, stress can be categorized as acute or chronic, while its etiology differentiates it into natural and human-induced stress [8]. Physical stress is closely associated with TMD, as it can directly or indirectly induce pain stimuli in the temporomandibular joint (TMJ), leading to inflammation or joint injury, which are major etiological factors in TMD development [11]. Direct physical stress involves direct contact with the TMJ, such as microtrauma, macrotrauma, and parafunctional habits like bruxism [12]. Indirect physical stress results from physical activity that does not directly impact the TMJ but triggers neurogenic inflammation and ischemia-reperfusion injury [13]. Indirect stress is mediated by a pro-inflammatory cytokine response, making recurrent physical stress a strong etiological factor for TMD [14,15]. Furthermore, indirect physical stress contributes to TMD pathogenesis through cytokine-induced inflammation [16]. Consequently, individuals engaging in high-intensity physical activities are at a greater risk of developing TMD than the general population.

A study by Freiwald [17] reported that the prevalence of TMD ranges from 11.7% to 100% among athletes, compared to 11.11% to 14.3% in non-athletes. Similarly, Alrowdan et al. (2023) [17] observed a high frequency of TMD among weightlifters in Saudi Arabia, while Hong (2023) [19] demonstrated how stress can be classified using modern computational methods. Bird and Beecroft (2024) [18] emphasized the importance of accurate diagnosis. These findings indicate that athletes are more prone to TMD due to excessive physical strain compared to non-athletes. The study also found a correlation between the stomatognathic system and distant muscle groups, emphasizing the need to consider TMJ health to prevent orofacial complications and maintain athletic performance [17–19]. Masticatory muscle contractions during physical exercise can cause myofascial pain, discomfort, and impairment of sports performance [20]. An imbalance between stress and recovery due to intense physical activity may disrupt physiological adaptation. Currently, there is limited research on the relationship between physical stress and TMD risk, particularly in amateur athletes who often lack medical monitoring comparable to professionals. This creates a research gap that justifies the present study.Therefore, this study aimed to investigate the influence of chronic physical exercise at different intensities on the incidence of TMD. Physical activity levels were assessed using the Global Physical Activity Questionnaire (GPAQ), while temporomandibular disorder (TMD) was diagnosed using the Diagnostic Criteria for TMD (DC/TMD). The DC/TMD, published by the International RDC/TMD Consortium Network and Orofacial Pain Special Interest Group in 2014, is considered more accurate and valid than the previous RDC/TMD system [21]. Clinical surveys were conducted among sports community members at Universitas Airlangga, including futsal, basketball, badminton, and volleyball athletes.

2. Material and methods

This study was an observational analytic clinical study with a cross-sectional survey design, conducted to analyze the association between chronic physical activity and temporomandibular disorder (TMD) symptoms among amateur athletes. Ethical clearance was obtained from the Health Research Ethics Committee of the Faculty of Dental Medicine, Universitas Airlangga (Certificate No. 0686/HRECC.FODM/VII/2024, issued July 4, 2024). The study was carried out in accordance with the Declaration of Helsinki. All participants were informed in detail about the aims, procedures, potential risks, and benefits of the study, and written informed consent was obtained from each subject prior to participation, including consent for the use of anonymized data in publications.

The study population consisted of male amateur athletes who were active members of futsal, basketball, badminton, or volleyball communities at Universitas Airlangga during the 2024 academic period. Inclusion criteria were: male gender, age between 18 and 40 years, active membership in one of the sports communities, regular physical training for at least the past nine months, physical health, and willingness to participate by signing informed consent. Exclusion criteria included: individuals with special needs or communication impairments, severe systemic diseases or those undergoing chemotherapy or radiotherapy, history of hospitalization due to TMD, and incomplete or withdrawn participation. Sampling was conducted using a purposive non-random technique, with only those fulfilling the inclusion and exclusion criteria enrolled.

Scoring followed the GPAQ analysis guide, yielding metabolic equivalent tasks (METs) and categorizing activity levels as low, moderate, or high. Previous studies have shown that the GPAQ has acceptable validity (Spearman's rho 0.45–0.57) and moderate-to-strong reliability ($\kappa = 0.67–0.73$) (Bull, Maslin and Armstrong, 2009). The second instrument was the Symptoms Questionnaire (SQ) for TMD, based on the Diagnostic Criteria for TMD (DC/TMD, Axis I). This instrument consists of 14 questions related to pain in the temporomandibular region, headaches, joint sounds, and locking episodes. The Indonesian version has been validated and proven reliable, with a Cronbach's alpha of 0.890, indicating high internal consistency (Riyanti and Nizar, 2020).

To complement the questionnaires, each participant underwent a standardized clinical examination according to the DC/TMD protocol (Schiffman et al., 2014). The examination included palpation to identify pain in the temporomandibular region and associated muscles during the past 30 days, assessment of headache location, evaluation of incisal relationships (overjet, overbite, and midline deviation measured in millimeters), observation of mandibular movement patterns during opening, lateral, and protrusive movements, measurement of unassisted and assisted maximum mouth opening, detection of temporomandibular joint sounds such as clicking or crepitus, and palpation of muscles with a standardized pressure of 0.5–1 kg to determine familiar pain, familiar headache, and referred pain. All data were recorded in Microsoft Excel spreadsheets stored securely via Google Drive access. No specialized chemicals were used in this study.

Data scoring followed established guidelines. Physical activity levels were calculated based on MET-minutes per week using the GPAQ scoring system, and participants were categorized into low, moderate, or high activity groups. TMD diagnosis and classification were determined by integrating the results of the SQ TMD and clinical examinations according to the decision tree outlined in the DC/TMD Axis I protocol. All statistical analyses were performed using SPSS for Windows, Version 29 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to present demographic and clinical data. The association between physical activity levels and TMD incidence was evaluated using the Chi-square (χ^2) test. A significance threshold of $\alpha = 0.05$ was applied; p-values ≤ 0.05 were considered statistically significant, whereas p-values ≥ 0.05 indicated no significant association.

3. Result

In this study, respondents' characteristics were described by sports community and age distribution. Among the 64 respondents, the majority participated in futsal (23; 35.9%), followed by basketball (17; 26.6%), badminton (15; 23.4%), and volleyball (9; 14.1%). Regarding age, most respondents were 21 years old (23; 35.9%), followed by 20 years (14; 21.9%) and 23 years (10; 15.6%). Smaller proportions were aged 22 (6; 9.4%), 19 (5; 7.8%), 18 (4; 6.3%), and 24 years (2; 3.1%). Overall, respondents were predominantly in their early twenties. Among the 64 respondents from futsal, basketball, badminton, and volleyball communities, most (33; 51.6%) had high physical activity levels, followed by moderate (27; 42.2%) and low (4; 6.3%). The incidence of TMD among 64 respondents from futsal, basketball, badminton, and volleyball communities was assessed using a TMD symptom questionnaire and physical examination based on DC/TMD criteria. A total of 40 respondents (62.5%) were identified with TMD, while 24 (37.5%) had no TMD. The most frequently reported symptom was joint sounds (22 respondents), followed by headache (21 respondents) and temporomandibular joint pain (12 respondents). To analyze the relationship between physical activity level and the incidence of TMD among respondents, a Chi-Square test was performed. The data showed that TMD incidence was more frequent among respondents with high physical activity (26; 40.6%) compared to those with moderate (13; 20.3%) and low activity levels (1; 1.6%). Conversely, among respondents without TMD, 7 (10.9%) reported high activity, 14 (21.9%) moderate activity, and 3 (4.7%) low activity. The Chi-Square test at a 5% significance level ($\alpha = 0.05$) yielded a p-value of 0.014, indicating a significant association between physical activity level and TMD incidence ($p < 0.05$).

Table 1 Distribution of Respondents Based on Characteristics, Physical Activity Levels, and Incidence of Temporomandibular Disorder (TMD)

No.	Sample characteristics	Total (n)	Percentage (%)	
Sports Community				
1.	Futsal	23	35.9	
2.	Basketball	17	26.6	
3.	Badminton	15	23.4	
4.	Volleyball	9	14.1	
Total		64	100	
Age				
1.	18 years old	4	6.3	
2.	19 years old	5	7.8	
3.	20 years old	14	21.9	
4.	21 years old	23	35.9	
5.	22 years old	6	9.4	
6.	23 years old	10	15.6	
7.	24 years old	2	3.1	
Total		64	100	
Physical Activity Levels based on GPAC				
1.	High	33	51.6	
2.	Moderate	27	42.2	
3.	Low	3	6.3	
Total		64	100	
Incidence of TMD based on DC/TMD				
1.	Identified with TMD	40	62.5	
2.	Not identified with TMD	24	37.5	
Total		64	100	
TMD Symptoms				
1.	Joint sounds	22	40	
2.	Headache	21	38.2	
3.	Temporomandibular joint pain	12	21.8	
Total		55	100	
TMD Incidence				
TMD Incidence (Chi-Square = 0,014)		Physical Activity Levels		
		Low	Moderate	High
1.	Positive	1 (1,6%)	13 (20,3%)	26 (40,6%)
2.	Negative	3 (4,7%)	14 (21,9%)	7 (10,9%)
Statistical Analysis (Chi-Square Test)				

TMD Incidence vs. Physical Activity Level	p = 0.014 (significant)		
TMD Incidence	Low	Moderate	High
Positive (TMD +)	1 (1.6%)	13 (20.3%)	26 (40.6%)
Negative (TMD –)	3 (4.7%)	14 (21.9%)	7 (10.9%)

This study demonstrated a significant association between physical activity intensity and the incidence of temporomandibular disorder (TMD) among amateur athletes (p = 0.014). The greater prevalence of TMD in the high-intensity group supports the hypothesis that excessive physical load contributes to musculoskeletal dysfunction within the stomatognathic system. Repetitive microtrauma, muscular overuse, and progressive articular degeneration of the temporomandibular joint (TMJ) are recognized as key biomechanical pathways in TMD pathogenesis [13]. Continuous contraction of the masticatory muscles during intense training increases intra-articular pressure, decreases synovial lubrication, and accelerates the mechanical wear of fibrous and cartilaginous components, ultimately reducing joint resilience and adaptability [9,14].

From a physiological standpoint, prolonged and strenuous exercise activates the hypothalamic–pituitary–adrenal (HPA) axis and the sympatho–adreno–medullary (SAM) system, elevating circulating cortisol and catecholamine levels [10]. Sustained exposure to these stress mediators suppresses collagen synthesis, enhances protein catabolism, and impairs tissue repair, thereby compromising TMJ structural integrity. Moreover, excessive exercise triggers systemic oxidative stress and the upregulation of pro-inflammatory cytokines such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α), which sensitize peripheral nociceptors and amplify central pain signaling [36,37]. These mechanisms suggest that physical and psychological stressors share convergent neuroendocrine and inflammatory pathways in the development of TMD [36].

The etiopathogenesis of TMD is multifactorial, encompassing biomechanical, psychosocial, hormonal, inflammatory, and behavioral factors that interact synergistically to influence individual susceptibility [38]. According to Ohrbach and Sharma (2023), repetitive mechanical overloading and parafunctional habits such as clenching or bruxism act as chronic microtraumatic stimuli that disrupt joint homeostasis and facilitate degenerative remodeling of TMJ structures. Psychological stress, frequently associated with competitive pressure and fatigue accumulation in athletes, further potentiates muscle hyperactivity and inflammatory cytokine release, aggravating joint pain and dysfunction [36–38]. Hormonal regulation has also been implicated in TMD pathophysiology, with estrogen shown to modulate collagen turnover and nociceptive thresholds within TMJ tissues [39]. Nevertheless, the present study exclusively involved male athletes to minimize hormonal variability and isolate the effects of physical and physiological stress as primary etiological factors. This methodological approach strengthens the internal validity of the findings and provides a clearer understanding of mechanical stress–driven mechanisms in TMD onset.

Epidemiological evidence further supports these findings. Valesan et al. (2021) reported that TMD prevalence peaks among young adults and individuals exposed to repetitive physical or psychological stress, aligning with the demographic characteristics of the current sample [39]. Moreover, studies by Freiwald et al. (2020) and Crincoli et al. (2022) revealed that athletes participating in contact or endurance sports exhibit higher rates of TMJ pain, joint clicking, and articular remodeling, likely due to cumulative stress without adequate recovery [38,39]. Collectively, these data reinforce that chronic imbalance between exercise intensity and recovery capacity constitutes a major risk factor for the onset and persistence of TMD.

Clinically, these results highlight the importance of implementing preventive strategies and early screening for TMD among athletes. Regular evaluation using standardized instruments such as the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) enables timely diagnosis and management before chronic pain or irreversible joint damage occurs [9]. A multidisciplinary approach integrating dental medicine, sports physiology, and psychological support is essential to maintain musculoskeletal harmony and optimize performance. Ultimately, balancing training intensity, recovery, and stress regulation forms the cornerstone of preventive frameworks for minimizing temporomandibular dysfunction in physically active populations [36–39].

4. Conclusion

The higher the intensity of physical activity, the higher the incidence of TMD in amateur athletes.

Compliance with ethical standards

Acknowledgments

The authors would like to express their deepest gratitude to Dr. Ni Putu Mira Sumarta, drg., Sp.B.M.M., Subsp.T.M.T.M.J.(K), and Andra Rizqiawan, drg., Ph.D., Sp.B.M.M., Subsp.T.M.T.M.J.(K)., FICS, for their continuous guidance, support, and valuable advice throughout the study. Appreciation is also extended to the Department of Oral and Maxillofacial Surgery, Faculty of Dental Medicine, Universitas Airlangga, for providing the facilities and assistance necessary for conducting this research. The authors are sincerely thankful to all participants and sports communities at Universitas Airlangga for their cooperation. Special thanks are conveyed to family and friends who offered encouragement and motivation during the research process.

Disclosure of Conflict of Interest

The authors declare that they have no conflict of interest to disclose.

statement of Ethical approval

This study received ethical approval from the Health Research Ethics Committee of the Faculty of Dental Medicine, Universitas Airlangga, Surabaya, Indonesia (Certificate No. 0686/HRECC.FODM/VII/2024, issued July 4, 2024). The research was conducted in accordance with the Declaration of Helsinki and the ethical standards of the institutional committee.

statement of Informed consent

All participants were informed in detail about the objectives, procedures, benefits, and possible risks of the study. Written informed consent was obtained from each participant prior to data collection, including consent for publication of anonymized data and findings for scientific purposes.

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