JOMADS
Journal of Maxillofacial and Dental Sport Science

OPEN ACCESS
Journal of Maxillofacial and Dental Sport Science **2026**, Volume 1, Issue 1
E-ISSN Online: xxxx-xxxx
https://doi.org/10.26470/jomads.v1i1.53254

Review Article

Saliva and Oral Health in Athletes: A Scoping Review

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Citation: Ramaniasari SM, Hendrawan C, Hasudungan DS. Saliva and Oral Health in Athletes: Scoping Review. *Journal of Maxillofacial and Dental Sport Science.* 2026, Vol. 1, No. 1. https://doi.org/10.26470/jomads.v1i1.53254

Received: April 30, 2026
Revised: May 26, 2026
Accepted: June 18, 2026

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Abstract

Background: Oral health is a critical component of overall health and athletic performance; however, it is frequently overlooked in sports science. Saliva plays a fundamental role in maintaining oral homeostasis through its buffering capacity, antimicrobial properties, and contribution to remineralization processes. Despite the growing body of research on salivary biomarkers, current evidence remains fragmented and lacks integration. **Methods:** This scoping review followed the PCC framework, with literature searches conducted in PubMed, ScienceDirect, and ProQuest using Boolean strategies. The review was guided by PRISMA-ScR reporting standards and JBI methodological guidelines. **Results:** A literature search across PubMed, ScienceDirect, and ProQuest identified 2,777 records published within the last 10 years. Following screening, duplicate removal, and eligibility assessment, 12 studies met the inclusion criteria and were included for final data extraction and synthesis. **Discussion:** The included studies indicate that physical activity modulates a broad spectrum of salivary biomarkers, encompassing pH, cortisol, secretory immunoglobulin A (sIgA), microbial composition, and total antioxidant capacity (TAC), which collectively reflect oral health integrity, immune regulation, oxidative balance, and physiological adaptation in athletic populations. **Conclusion:** This review is limited by the predominance of observational studies, methodological heterogeneity, and inadequate control of confounding factors such as diet, hydration, and oral hygiene. Future research should prioritize standardized, longitudinal, and experimental approaches to clarify causal relationships and optimize modifiable factors influencing exercise-related salivary changes.

Keywords: Saliva; Oral health; Athletes; Salivary biomarkers; Physical exercise

INTRODUCTION

Oral health is a critical component of overall health and athletic performance; however, it is frequently overlooked in sports science. Evidence has shown that athletes are at increased risk of oral diseases, including dental caries, periodontal conditions, and dental erosion, which may negatively affect both health status and performance outcomes[1]. These conditions are often associated with sport-specific factors such as high training intensity, frequent consumption of carbohydrate-rich or acidic sports drinks, dehydration, and physiological stress[2]. Consequently, understanding the underlying biological mechanisms linking athletic activity and oral health is essential for improving athlete care.

Saliva plays a fundamental role in maintaining oral homeostasis through its buffering capacity, antimicrobial properties, and contribution to remineralization processes[3]. In addition to its protective functions, saliva has gained increasing attention as a non-invasive diagnostic fluid capable of reflecting both local and systemic physiological changes. Various salivary biomarkers, including secretory immunoglobulin A (sIgA), cortisol, alpha-amylase, inflammatory cytokines, and oxidative stress markers, have been widely investigated in the context of exercise physiology[4]. These biomarkers provide valuable insights into immune function, stress responses, and inflammatory status in athletes.

Despite the growing body of research on salivary biomarkers, current evidence remains fragmented and lacks integration[5]. Although numerous studies have independently examined oral disease prevalence or exercise-induced salivary biomarkers, no comprehensive synthesis has integrated these findings to explain how salivary alterations mediate oral health risks across athletic populations[2]. Many studies have focused on individual biomarkers or specific sports populations without examining their combined impact on oral health outcomes. Furthermore, inconsistencies exist regarding the effects of exercise intensity and duration on salivary parameters, particularly in relation to immune function and inflammation. Importantly, the relationship between salivary alterations and oral health in athletes has not been comprehensively synthesized across different study designs and populations.

Therefore, a clear research gap exists in understanding how exercise-induced changes in saliva influence oral health in athletes. Addressing this gap is essential to establish saliva as a reliable biomarker for monitoring both physiological stress and oral health risk in athletic populations. The novelty of this study lies in its integrative approach, combining evidence on salivary biomarkers, exercise responses, and oral health outcomes within a single framework, which has not been systematically explored in previous literature. The findings of this review are expected to provide important clinical and practical implications by supporting the use of salivary biomarkers as non-invasive tools for monitoring athlete health. Additionally, this study aims to inform preventive strategies and promote interdisciplinary collaboration between sports medicine and oral healthcare professionals. Therefore, this scoping review aims to map and synthesize the existing evidence on the relationship between salivary parameters and oral health among athletes.

METHODS

This scoping review was conducted in accordance with the Population–Concept–Context (PCC) framework to ensure a structured and comprehensive approach to evidence mapping. The review question was defined as follows: “What is the relationship between salivary parameters and oral health outcomes among athletes?”. A systematic literature search was performed across electronic databases, including PubMed, ScienceDirect, and ProQuest, employing a Boolean search strategy to identify relevant studies. The search string combined key terms related to saliva, oral health, and athletic populations, namely athlete AND saliva AND oral health. To enhance the comprehensiveness of the search, manual screening of reference lists was also undertaken.

Eligibility criteria were predefined and applied to ensure methodological rigor. Studies were included if they were full-text articles published in English, accessible via the Universitas Negeri Surabaya institutional access, and published within the timeframe of 2016 to 2026. Only original research articles investigating salivary characteristics in relation to oral health outcomes in athletic populations were considered. Review articles, editorials, commentaries, and short communications were excluded. Both observational and experimental study designs were deemed eligible. Duplicate records were identified and removed prior to the screening process.

The concept of interest encompassed salivary parameters, including but not limited to salivary flow rate, pH, buffering capacity, and immunological markers (e.g., salivary immunoglobulin A), while the context focused on athletic populations across various types and levels of sports participation. Oral health outcomes of interest included dental caries, periodontal conditions, dental erosion, and xerostomia.

Study selection was conducted independently by the two reviewers (S.M.R. and C.H), with discrepancies resolved through discussion or consultation with a third reviewer (D.S.H) where necessary. The reviewer independently performed critical evaluations utilizing JBI critical evaluation tools (Figure 1) depicts the flow diagram of the study selection process using PRISMA-ScR. Data extraction and charting were performed using a standardized and pre-validated Microsoft Excel form. Extracted variables included study design, participant characteristics, type of sport, salivary parameters assessed, oral health indicators, and key findings. The synthesized results were systematically organized into tabular formats using predefined data charting frameworks, ensuring consistency and transparency in reporting across included studies.

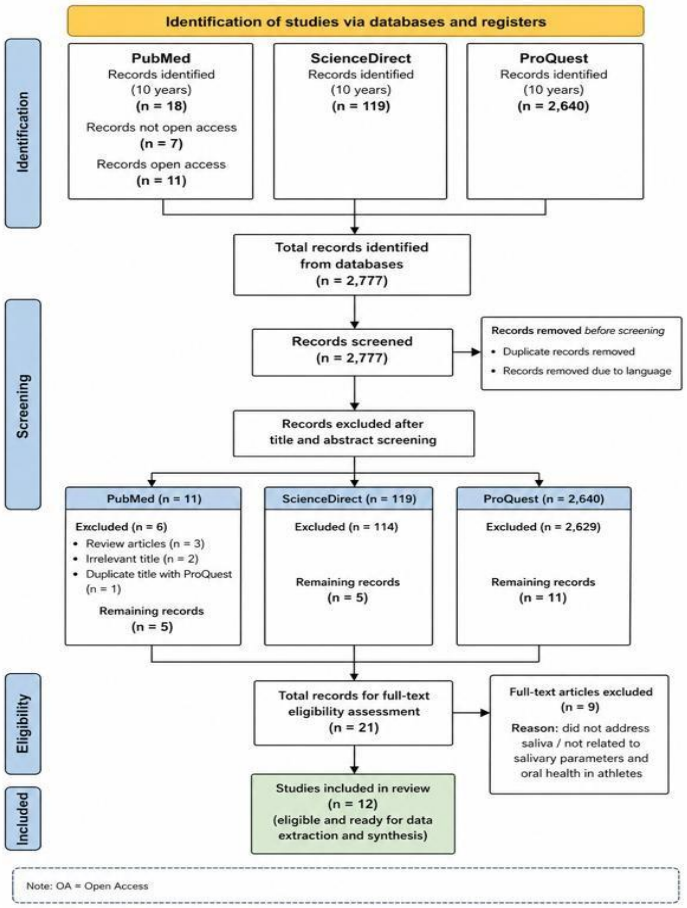


Figure 1. PRISMA-ScR flow diagram illustrating the study selection process

RESULTS

The study selection process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines. A comprehensive literature search was conducted across three electronic databases: PubMed, ScienceDirect, and ProQuest, limited to publications from the last 10 years. The initial search yielded a total of 2,777 records (PubMed: 18; ScienceDirect: 119; ProQuest: 2,640). From PubMed, 7 articles were excluded due to lack of open-access availability, resulting in 11 records eligible for screening. All retrieved records (n = 2,777) were then subjected to the screening process. During this stage, duplicates and

non-relevant studies were removed based on language restrictions and title and abstract screening. Specifically, in the PubMed database, 6 articles were excluded (3 review articles, 2 irrelevant titles, and 1 duplicate with ProQuest), leaving 5 studies. In ScienceDirect, 114 articles were excluded, resulting in 5 eligible studies. From ProQuest, 2,629 articles were excluded, leaving 11 studies. In total, 21 articles were retained after the screening phase and proceeded to full-text eligibility assessment. During the eligibility stage, 9 articles were excluded due to not addressing salivary parameters in relation to oral health among athletes. Consequently, a final total of 12 studies met all inclusion criteria and were included in the scoping review for data extraction and synthesis.

Data from the included studies were systematically extracted and summarized using a standardized data charting form. The included studies demonstrated that salivary biomarkers, ranging from immunological and inflammatory markers to oxidative stress indicators, serve as valuable non-invasive tools for assessing physiological responses to exercise and their implications for oral health in athletes. The extracted information comprised: (a) author(s) and year of publication, (b) study design; (c) population; (d) output; and (e) conclusion. A descriptive summary of characteristics of the included articles is presented in (Table 1).

The methodological quality of the included studies was assessed using a modified *Joanna Briggs Institute* (JBI) critical appraisal approach. Overall, most studies demonstrated a moderate risk of bias, primarily due to limited control of confounding variables and the observational nature of the study designs. However, the majority employed valid and reliable measurement methods alongside appropriate statistical analyses, supporting the robustness of the findings. The assessment of risk of bias and quality can be detailed in (Table 2).

Table 1. Summary of descriptive characteristic of articles included in the present study

No	Author, Year	Type of Study	Population	Output	Conclusion
1	Heaney *et al.,* 2018[6]	Quasi-experimental	10 trained cyclists	**Free light chain (κ, λ) serum (mg/L)** Baseline *Pre exercise*: 23.23±2.85 *Post Exercice :* 23.44 ± 4.18 Post-intensified training *Pre-exercise:* 22.26±4.35 *Post-exercise*: 23.89±3.90 **IgA** Baseline *Pre exercise*: 1.86±0.51 *Post Exercice :* 1.94 ± 0.54 Post-intensified training *Pre-exercise:* 1.74±0.46 *Post-exercise*: 1.89±0.39	Intensified training increased salivary FLC levels, suggesting elevated oral inflammation
2	Minty *et al.,* 2018[7]	Case control study	24 professional rugby players (PRG) vs 22 control patients (CG)	PRG were characterized by a dysbiotic oral microbiota (Shannon Index: 3.32±0.62 in PRG versus 3.79±0.68 in CG; p=0.03) with an increase of Streptococcus (58.43 ±16.84 versus 42.60±17.45; p=0.005),	Rugby players exhibited oral dysbiosis and poorer oral health compared to controls

3	Peres *et al*., 2020[8]	Cross sectional study&longitudinal	115 female volleyball players (children)	**SIgA concentration (g/ml)** Beginner (n=24) : 181.4 [141.0–262.4] Intermediate (n=52) : 179.9 [138.7–308.6] Competitive (n=39) : 193.4 [133.2—350.1] **SIgA secretion rate (g/min)** Beginner (n=24) : 142.6 [76.7–231.4] Intermediate (n=52) : 130.4 [65.8–203.4] Competitive (n=39) : 126.5 [57.4–206.0] **Alpha Amylase activity (mol/s*l)** Beginner (n=24) : 17.5 [15.8–20.2] Intermediate (n=52) :17.5 [16.5–18.9] Competitive (n=39) : 17.6 [16.8–18.8]	Regular training did not significantly alter salivary SIgA levels
4	Peres *et al*., 2020[9]	Cross sectional study&longitudinal	120 female volleyball players (children)	**IL-6 (pg/ml)** Beginner : 2.08 [1.67–3.05] Intermediate : 1.94 [1.54–3.13] Competitive : 1.71[1.48–-3.33] **TNFα(pg/ml)** Beginner : 0.44 [0.25–0.61] Intermediate : 0.43 [0.29–0.56] Competitive : 0.48 [0.28–0.65]	Salivary cytokines showed no significant association with dental caries
5	Sevindik *et al*., 2024[10]	Observational	91 winter sports athletes (71 elite vs 20 novice)	**Salivary cortisol level** *Pre-competition* Snowboard: 276 ± 147 Ice hockey: 252 ± 148 Alpine skiing: 221 ± 158 Ski jumping: 165 ± 177 Biathlon: 637 ± 140 Control: 311 ± 79 Elite athlete:291 ± 216 *During match* Snowboard: 340 ± 232 Ice hockey: 279 ± 169 Alpine skiing: 311 ± 123 Ski jumping: 172 ± 127 Biathlon: 615 ± 144 Elite athlete: 321 ± 207 *Post-competition* Snowboard: 445 ± 195 Ice hockey: 381 ± 329 Alpine skiing: 401 ± 237 Ski jumping: 181 ± 136 Biathlon: 615 ± 142 Elite athlete:385 ± 267	Salivary stress biomarkers varied by sport and were negatively associated with oral health
6	Abdelrahman *et al*, 2023[11]	Cross sectional study	180 athletes (90 competitive swimmers vs 90 competitive	**Salivary pH** *Swimmer* (n=90) Before : 7.13 ± 0.35 After : 7.32 ± 0.37	Swimmers showed higher risk of dental erosion and altered salivary parameters

			rowers non-swimmers")	*Non-swimmer* (n=90) Before : 7.32 ± 0.35 After : 7.16 ± 0.30 **Salivary flow rate** *Swimmer* (n=90) Before : 1.12 ± 0.38 After : 0.96 ± 0.42 *Non-swimmer* (n=90) Before : 1.21 ± 0.54 After : 0.92 ± 0.40	
7	Matei, *et al.,* 2023[12]	Observational	173 children athletes (58 hockey players, 55 football players, and 60 children in the control group.	**Glutathione peroxidase (GPX)** *Hockey* : 435.351-691.694 *Football* : 355.943-588.25 *Control*: 149.129-284.185 **Superoxide dismutase (SOD)** *Hockey*: 7.904-49.943 *Football*: 0.071-81.639 *Control*: 34.596-90.594 **Total antioxidant capacity (TAC)** *Hockey*: 0.125-0.949 *Football*: 0.26-1.496 *Control*: 0.078-2.506	Salivary biomarkers reflected oxidative stress and were associated with oral health status
8	Borchers *et al*., 2022[13]	Cohort (pilot)	9 ultramarathon runners	**s-cortisol (µg/dL)** *Baseline* : 0.7±0.2 *After the ultramarathon* : 1.8 ±0.7 *After recovery* : 0.6 ±0.7 **s-testosterone (pg/mL)** *Baseline* : 325.3 ±248.6 *After the ultramarathon* : 298.3 ±262.0 *After recovery* : 313.4 ±291.0 **s-IL-1β (pg/mL)** *Baseline* : 6.2 ±8.7 *After the ultramarathon* : 6.6 ±10.4 *After recovery* : 9.4 ±12.2 **s-IL-6 (pg/mL)** *Baseline* : 0.7 ±1.1 *After the ultramarathon* : 0.9 ±0.7 *After recovery* : 0.8 ±1.3 **s-IL-8 (pg/mL)** *Baseline* : 28.6 ±39.7 *After the ultramarathon* : 59.9 ±60.5 *After recovery* :145.8 ±218.0 **s-IgA (µg/mL)** *Baseline* : 11.6 ±11.4	Strenuous exercise significantly altered salivary immune and inflammatory biomarkers

				After the ultramarathon : 32.4 ±61.4 *After recovery* :16.4 ±7.7 **s-α amylase (U/mL)** *Baseline* : 18.4 ±20.6 *After the ultramarathon* : 31.2 ±26.5 *After recovery* : 33.3 ±39.9 **s-aMMP-8 (pg/mL)** *Baseline* : 1749 ±1614 *After the ultramarathon* : 7422 ±8900 *After recovery* : 14834 ±23062	
9	Grzesiak-Gasek *et al*., 2025[14]	Experimental (pre-post)	30 basketball players	**Alpha Amylase (IU/L)** *Man* Before : 122.45 After : 200.00 *Female* Before : 62.00 After : 82.59 **Salivary cortisol level** *Man* Before : 1.29 After : 1.67 *Female* Before : 1.44 After : 2.27	Salivary responses to exercise differed between male and female athletes
10	Shukla *et al.,* 2025[15]	Cross sectional study	224 adults (pranayama vs control)	**Total Antioxidant Capacity/TAoC (mM Trolox)** *Pranayama group* (n=112) : 0.58 ±0.09 *Control group* (n=112) : 0.50 ±0.09 **Melondialdehyde (MDA) levels (mmol)** *Pranayama group* (n=112) : 0.44 ±0.09 *Control group* (n=112) : 0.61 ±0.11	Pranayama reduced oxidative stress and improved periodontal health indicators
11	Grzesiak-Gasek *et al.,* 2026[16]	Observation	50 young athletes (swimmer vs basketball player)	**Δα-amylase (%) (mean)** *Swimming* : 37.53 *Basketball* : 45.25 **Δprotein (%)** *Swimming* : 25.73 *Basketball* : 33.59 **ΔpH (%)** *Swimming* : 3.34 *Basketball* : 3.8 **ΔV (%) (Salivary flow rate)** *Swimming* : 44.01 *Basketball* : 39.76	Salivary biomarkers reflected physiological responses to training load.

12	Tripodi *et al*., 2024[17]	Cross sectional study	120 young athletes vs 30 controls	**pH value** *Swimming* Baseline : 7.91 ± 0.5905 Before training : 7.27 ± 0.8876 After training : 6.21 ± 0.3209§ *Soccer* Baseline : 7.49 ± 0.1026 Before training : 7.29 ± 0.3730 After training : 7.55 ± 0.2713 *Waterpolo* Baseline Before training After training *Skiing* Baseline : 7.62 ± 0.2466c Before training : 7.49 ± 0.6672 After training : 6.27 ± 0.3150 *Control group* Baseline : 7.12 ± 0.3869 **S. Mutans** *Swimming* : 20% *Soccer*: 60% *Waterpolo*: 70% *Skiing*: 26.67% *Control group*: 32.2% **Lactobacillus sp.** *Swimming* : 43.33% *Soccer*: 43.33% *Waterpolo*: 10% *Skiing*: 0% *Control group*: 15.5%	Dietary habits influenced salivary microbiota and increased caries risk

Table 2. Risk of bias assessment according to JBI critical appraisal

Author, Year	Type of Study	Inclusion Criteria Clear	Exposure Measurement Valid	Outcome Measurement Valid	Confounding Identified	Confounding Addressed	Statistical Analysis Appropriate	Risk of Bias
Heaney *et al.,* 2018[6]	Quasi-experimental	Yes	Yes	Yes	No	No	Yes	Moderate
Minty *et al.,* 2018[7]	Case control study	Yes	Yes	Yes	Yes	Yes	Yes	Low
Peres *et al*., 2020[8]	Cross sectional study&longitudinal	Yes	Yes	Yes	Yes	No	Yes	Moderate
Peres *et al*., 2020[9]	Cross sectional study&longitudinal	Yes	Yes	Yes	Yes	No	Yes	Moderate

Sevindik *et al*., 2024[10]	Observational	Yes	Yes	Yes	No	No.	Yes	Moderate
Abdelrahman *et al*, 2023[11]	Cross sectional study	Yes	Yes	Yes	Yes	Yes	Yes	Low
Matei, *et al.,* 2023[12]	Observational	Yes	Yes	Yes	Yes	No.	Yes	Moderate
Borchers *et al*., 2022[13]	Cohort (pilot)	Yes	Yes	Yes	No	No.	Yes	Moderate
Grzesiak-Gasek *et al*., 2025[14]	Experimental (pre-post)	Yes	Yes	Yes	No	No	Yes	Moderate
Shukla *et al.,* 2025[15]	Cross sectional study	Yes	Yes	Yes	Yes	Yes	Yes	Low
Grzesiak-Gasek *et al.,* 2026[16]	Observational	Yes	Yes	Yes	Yes	No.	Yes	Moderate
Tripodi *et al*., 2024[17]	Cross sectional study	Yes	Yes	Yes	Yes	No	Yes	Moderate

DISCUSSION

This scoping review demonstrates that physical exercise, particularly when characterized by high intensity or prolonged duration, exerts substantial effects on salivary composition and functional properties. A broad spectrum of salivary biomarkers, including immunological components (e.g., immunoglobulin A), stress-related hormones (e.g., cortisol), inflammatory mediators (e.g., cytokines), oxidative stress markers, as well as microbial indicators such as oral microbiota composition and pathogen-related profiles, were consistently shown to undergo significant alterations in response to exercise. These findings reinforce existing evidence that saliva serves as a highly sensitive and non-invasive biological medium capable of reflecting both local oral and systemic physiological adaptations associated with physical activity.[18]

The alterations observed in salivary parameters may be largely attributed to physiological stress responses induced by exercise. During vigorous or prolonged physical activity, activation of the hypothalamic–pituitary–adrenal (HPA) axis stimulates elevated cortisol secretion, which can negatively modulate mucosal immune function. Notably, salivary immunoglobulin A (IgA), a critical component of the oral immune defense system, has consistently been reported to decline following high-intensity or extended-duration exercise, potentially compromising oral immune protection.[19]. This is consistent with studies conducted by Heaney *et al*. (2018) and Borchers et al. (2022), which demonstrated a significant increase in salivary biomarkers, particularly IgA[613]. Salivary IgA plays a crucial role in protecting the oral cavity against microbial invasion and maintaining mucosal homeostasis. Therefore, reductions in IgA levels may increase susceptibility to infections and oral diseases in athletes[20]

However, in the study by Peres et al. (2020), regular training did not significantly increase sIgA levels. The lack of significant sIgA elevation may be explained by chronic physiological adaptation to regular training, resulting in a relatively stable mucosal immune response over time[21]. In well-trained individuals, habitual exercise may not provide sufficient additional immunological stimulus to significantly increase sIgA levels, particularly when baseline immune function has already adapted

to consistent physical stress[22]. Some studies found no significant changes in salivary IgA following moderate exercise, whereas others reported reductions after high-intensity training. These discrepancies are supported by previous research suggesting that the effects of exercise on salivary IgA depend on factors such as exercise intensity, duration, hydration status, and individual variability[23]

Exercise-induced changes in salivary secretion and mucosal immunity, particularly involving biomarkers such as salivary immunoglobulin A (sIgA), can modify the oral environment and potentially reshape microbial communities[21]. Alterations in the microbial environment of the oral cavity have likewise been demonstrated in studies by Minty et al. (2018) and Tripodi et al. (2024). Moderate exercise is generally associated with improved immune surveillance and oral ecological balance, whereas prolonged high-intensity training or overtraining may impair mucosal immunity and contribute to microbial dysbiosis[23]. Additional exercise-related physiological stress may further influence oral microbial composition through immune modulation and changes in oral homeostasis[24] Salivary pH is increasingly recognized as an important biomarker in sports science because it reflects alterations in oral homeostasis, hydration status, buffering capacity, and physiological stress during physical activity[26]. Regular physical activity may contribute to adaptive changes in salivary composition, but excessive or high-intensity training may exacerbate acidic shifts and oral physiological stress, particularly when combined with inadequate hydration or nutritional challenges[27]. A significant reduction in salivary pH was similarly reported in the study conducted by Tripodi et al. (2024). In contrast, studies by Abderahman et al. (2023) and Grzesiak-Gasek et al. (2026), including observations in swimming athletes, reported only minimal or statistically non-significant changes in salivary pH levels. Because swimmers were not entirely deprived of water intake during training sessions, adequate hydration may have been maintained, thereby helping preserve salivary buffering capacity and preventing substantial declines in pH levels. Consistently, previous studies examining rehydration in young athletes have demonstrated that water consumption can mitigate exercise-induced reductions in salivary pH[28]

Physical exercise substantially influences total antioxidant capacity (TAC) by increasing reactive oxygen species (ROS) production, which stimulates endogenous antioxidant defense systems. Acute strenuous exercise may transiently elevate oxidative stress and challenge antioxidant reserves, whereas regular training can induce adaptive upregulation of antioxidant defenses over time[29]. These repeated physiological adaptations may strengthen resistance to oxidative damage and enhance total antioxidant capacity in trained individuals[30].

CONCLUSION

This review has several limitations. Most included studies were observational, limiting causal inference. In addition, many studies did not adequately control for confounding factors such as diet, hydration, and oral hygiene, which may influence both salivary parameters and oral health outcomes. Variability in study design, population characteristics, and salivary biomarkers assessed also limits comparability across studies. Future studies should focus on longitudinal and experimental designs to better establish causal relationships between exercise, salivary changes, and oral health. Standardization of saliva collection methods and biomarker assessment is also needed. Furthermore, research should explore the role of modifiable factors such as nutrition, hydration, and recovery strategies in mitigating exercise-induced alterations in saliva.

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