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Physical Activity, Hydration, and Oral Health in Physical Education and Sports

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Abstract

Objective: To examine the relationship between hydration habits, physical activity, and oral health in students' physical education and sport (PES), focusing on water intake before, during, and after training, consumption of sugary and sports drinks, dry mouth, and use of additional oral hygiene products. **Materials and Methods:** A cross-sectional study was conducted among 121 students (67 males, 54 females; 18–25 years) engaged in regular physical activity. Data were collected via a 14-item structured questionnaire and analyzed using descriptive statistics, χ^2 goodness-of-fit tests, Cramer's V, and Spearman's rank correlation to assess the relationships between hydration, physical activity, and oral health indicators. **Results:** Most students reported regular physical activity, with 89.2% training ≥3 times per week and 76% training >60 minutes per session. Daily water intake exceeded four glasses for 70.2% of students, though 29.7% consumed insufficient fluids. During training, 9.9% did not drink water, and 44.6% experienced dry mouth at least occasionally. Sports and sugary drinks were consumed regularly by 16.6% and 4.1%, respectively. All students brushed their teeth at least twice daily, but only 20.7% used additional hygiene products. χ^2 and Cramer's V analyses revealed statistically significant deviations from uniform responses ($p < 0.01$), with moderate-to-very strong patterns in hydration, training, oral hygiene, and awareness of hydration's impact on oral health. Spearman correlations revealed that higher water intake was negatively associated with dry mouth ($\rho = -0.41$ to -0.48), dry mouth was positively associated with oral problems ($\rho = 0.42$), and consumption of sports/sugary drinks was moderately positively correlated with oral problems ($\rho = 0.29–0.35$). Physical activity frequency and duration were positively associated with dry mouth ($\rho = 0.27–0.34$), while additional oral hygiene use was negatively associated with oral problems ($\rho = -0.31$). **Conclusion**: Students PES generally maintain adequate hydration and oral hygiene habits, but certain risk behaviors persist, including inadequate fluid intake during exercise, consumption of acidic/sugary drinks, and limited use of additional hygiene products. The observed correlations underscore the link between hydration practices, physical activity, and oral health outcomes.

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Introduction

The modern and accelerated way of life significantly contributes to the rise of chronic non-communicable diseases, among which diabetes mellitus and cardiovascular diseases are the most common. Unhealthy diets and lack of physical activity are responsible for more than 60% of the total global mortality from these diseases [1]. Although students of physical education and sports generally achieve higher levels of physical activity compared to the general population, their behavioral patterns—including hydration and oral hygiene habits—can still pose specific health risks. Particularly concerning is the growing number of young people with obesity and sedentary lifestyles, which contributes to the earlier onset of metabolic disorders and further emphasizes the importance of prevention and the adoption of healthy lifestyle habits, even among students.

Physical activity is one of the key factors in the prevention, treatment, and management of most chronic non-communicable diseases. Regular exercise contributes to the prevention and treatment of cardiovascular diseases, stroke, and diabetes, as well as reducing obesity, improving mental health, and increasing insulin sensitivity [2,3]. Additionally, physical activity helps prevent hypertension and excessive body weight and can enhance cognitive abilities, quality of life, and overall well-being [4,5]. Whether the goal is improving health, physical appearance, or achieving a better psychological sense of life quality, physical activity must be regular, continuous, and conducted under professional supervision, especially in the case of complex kinesitherapy programs. Aerobic exercises, strength training, and high-intensity interval training (HIIT) have proven effective in controlling risk factors associated with type II diabetes, including obesity, hypertension, dyslipidemia, and physical inactivity [2,6]. The benefits of engaging in sports activities for maintaining physical and mental health are numerous. Regular physical activity increases energy expenditure, helps maintain optimal body weight, prevents obesity, and improves cardiopulmonary function. It also contributes to lowering blood pressure, reducing blood fat and glucose levels, and strengthening muscle strength and endurance, which facilitates daily activities with less fatigue. During physical activity, endorphins are released, positively affecting psychological health by reducing stress, improving mood and self-confidence, and enhancing concentration and learning ability. Physical inactivity and excess body weight are among the leading causes of mortality worldwide and represent significant risk factors for cardiovascular, musculoskeletal, and malignant diseases [7]. Although physical activity positively affects metabolic and cardiovascular health, its effectiveness largely depends on adequate hydration, which is essential for maintaining metabolic balance, physical performance, and oral health. Moderate-intensity aerobic activity reduces glucose levels during exercise, while values normalize during recovery [8]. Aerobic exercise, strength training, and HIIT improve insulin sensitivity and positively affect body composition by reducing visceral fat and improving the lipid profile [9,10].

In addition to physical activity, adequate hydration and oral health also play a key role in the optimal functioning of sports students. Water constitutes 50–70% of body mass and is essential for the proper functioning of cells, tissues, and organs, participating in waste elimination, body temperature regulation, joint lubrication, and protection of sensitive tissues. Insufficient fluid intake can cause fatigue and reduced energy levels. Continuous fluid replenishment is necessary due to daily losses through breathing, sweating, and excretion. The recommended daily fluid intake is approximately 3.7 liters for men and 2.7 liters for women, with around 20% coming from food [11]. Hydration is achieved through water-rich foods and beverages, while the intake of sugary drinks is recommended to be limited. Adequate fluid intake can be assessed based on thirst and urine color, while excessive intake can also have serious consequences. Non-alcoholic beverages, especially those rich in sugars and acids, lower saliva pH, cause enamel demineralization, and promote the growth of acidogenic bacteria, increasing the risk of caries, gingivitis, enamel erosion, dysbiosis of the oral microbiome, and other oral diseases [12-14]. Daily consumption of non-carbonated, sweetened sports and energy drinks is widespread among adolescents, students, and athletes. Their popularity is based on the belief that these drinks reduce fatigue and contribute to faster recovery, potentially enhancing cognitive and physical performance [15]. Hot beverages such as tea and coffee also affect oral health, but polyphenols in tea may have a protective effect, while added sugar or artificial sweeteners reduce these benefits. Studies show that frequent consumption of carbonated drinks significantly lowers saliva pH to levels that favor enamel demineralization and the development of caries [11].

Dental caries is one of the most common non-communicable diseases, and its occurrence is associated with high-calorie diets and reduced physical activity. Unhealthy eating habits and poor oral hygiene increase the risk of overweight and obesity [16-19]. Prolonged hyperglycemia can cause periodontal diseases, dry mouth, tooth mobility, oral infections, and an increased risk of caries [20]. The high prevalence of caries and tooth discoloration indicates that tooth brushing alone is not enough to neutralize frequent acid exposure. Consumption of sugar-rich sports drinks, inadequate oral hygiene, and irregular dental check-ups contribute to the development of caries, tooth erosion, and periodontal diseases [21-24]. A study by de la Parte et al. [25] shows that elite athletes, especially individuals and endurance athletes, have poorer oral health due to high carbohydrate intake and lifestyle. Oral health depends on hygiene, diet, training intensity, and potential use of prohibited substances. Dental caries, periodontal diseases, and periapical infections can act as infectious foci, causing systemic inflammation that reduces physical fitness and sports performance [26,27].

Physical activity, hydration, and oral health are key components of overall health for students, especially those studying physical education and sports. Analyzing habits and related risks allows for the identification of gaps in knowledge and practice, as well as the creation of targeted educational programs that can promote healthier lifestyles, better sports performance, and long-term prevention of health problems. Increased frequency and intensity of training in sports students simultaneously increase the need for adequate hydration. Insufficient or inadequate hydration can lead to reduced performance, fatigue, and increased risk of injury [28]. Recent research among students shows that knowledge and attitudes about oral health significantly influence hydration habits and beverage choices, with students often facing additional barriers in maintaining healthy habits [23,29]. Oral health is often neglected among young athletes, even though it directly affects overall health and sports performance. Dental and gum problems not only impair quality of life but can also negatively impact athletes' recovery.

Severe dental injuries or infections may temporarily prevent training and competition, while minor issues reduce intensity and efficiency [30]. Research results show that 20–30% of athletes report a negative impact of oral health on training or performance, 35% have difficulties with nutrition and fluid intake, 17% with smiling and social interactions, and 15% with relaxation. A comprehensive analysis of the relationship between physical activity, hydration, and oral health in physical education and sports students indicates that these components are inseparably linked and together shape quality of life and sports performance. Insufficient hydration, inadequate dietary habits, and neglect of oral hygiene can have cumulative negative effects, from reduced training efficiency to increased risk of injury and disease. Implementing systematic educational and practical interventions in educational institutions can be a key step toward creating a generation of athletes who equally value physical fitness and oral health as the foundation for success and well-being.

The aim of the study was to examine the relationship between hydration habits and frequency of physical activity with oral health status, with a special focus on water intake before, during, and after training, consumption of sports and sweetened drinks, occurrence of dry mouth, and the application of additional oral hygiene measures.

Material and Methods

Participants and Study design

The study was conducted as a descriptive, cross-sectional survey among students of Physical Education and Sports at universities in East Sarajevo and Banja Luka, aiming to examine the relationship between hydration habits, frequency of physical activity, and oral health. This study was not designed to compare specific sports disciplines. The survey was conducted on a voluntary basis during December 2025/2026. The sample included 121 students, of whom 67 (55.38%) were male and 54 (44.62%) female, aged 18–25 years, who regularly participate in physical activities.

Ethical consideration

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki, ensuring participant anonymity, voluntary participation, and the right to withdraw from the study at any time. The study was approved by the Ethics Committee of the Faculty of Physical Education and Sport, University of Banja Luka, on December 16 (No. 11/1.1054/25).

Data Collection

Data were collected using a structured questionnaire (Table 1) consisting of 14 questions divided into several sections: frequency and duration of physical activity, daily water intake, water intake before, during, and after training, consumption of sports and sugary drinks, experience of dry mouth, oral hygiene practices, use of additional oral hygiene products, presence of cavities or gum inflammation in the past year, perception of the impact of hydration on oral health, and identification of major challenges in maintaining oral health during training. The questionnaire was administered in paper format, with prior explanation of the study objectives and informed consent obtained from all participants.

Data Analysis

Collected data were analyzed using SPSS, applying descriptive statistics for basic sample characterization (frequencies, percentages, mean values). The χ^2 goodness-of-fit test was used to assess deviations from a uniform distribution, alongside calculation of Cramer's V as a measure of effect size. Cramer's V quantifies the strength of associations and the expression of behavioral patterns, interpreted as follows: 0.10–0.19 – small effect; 0.20–0.39 – moderate effect; 0.40–0.59 – strong effect; ≥0.60 – very strong effect. Additionally, Spearman's rank correlation was applied to evaluate the relationships between ordinal variables related to hydration, physical activity, and oral health outcomes. This approach was used to identify questions where students exhibited dominant, stable, and statistically significant patterns in physical activity, hydration, and oral health habits, as well as areas with greater variability and potential for further education.

Results

The results are presented as absolute numbers and percentages to quantify patterns of habits, the frequency of risk behaviors, and the prevalence of oral health issues, with a particular focus on students who consume insufficient water, frequently drink sports or sugary beverages, and report symptoms of dry mouth. These factors are key contributors to the development of caries, enamel erosion, and gum inflammation. The study, conducted on a sample of students, demonstrates a high level of physical activity and relatively well-established hydration habits, although clear oral health risks are present during longer and more intense training sessions. Data were analyzed using the χ^2 goodness-of-fit test, with Cramer's V calculated as a measure of effect size to assess the strength and consistency of observed patterns. Additionally, Spearman's rank correlation was applied to evaluate associations between hydration, physical activity, and oral health variables, providing insight into the relationships between behaviors and oral health outcomes.

The results presented in Table 1 show that most participants train regularly: 54 students (44.6%) exercise 3–4 times per week, 28 (23.1%) 5–6 times, and 26 (21.5%) daily, while only 13 students (10.7%) engage in minimal weekly activity of 1–2 sessions. This distribution clearly confirms that the sample is highly physically active, further emphasizing the importance of monitoring hydration and its effects on the oral cavity. Training duration reinforces this pattern: 73 students (60.3%) train for 60–90 minutes, 19 (15.7%) for more than 90 minutes, and 29 (24%) for 30–60 minutes, meaning that over three-quarters of participants train for more than an hour—a time threshold after which the risk of dehydration and reduced saliva flow significantly increases. Prolonged physical exertion is known to cause mouth breathing, fluid loss through sweating, and increased mucosal dryness, favoring the development of caries, fungal infections, and enamel erosion.

Analysis of daily hydration habits shows that 85 students (70.2%) consume more than four glasses of water per day, representing a positive pattern; however, 28 (23.1%) drink only 3–4 glasses, and 8 (6.6%) only 1–2 glasses, meaning nearly 30% of participants have insufficient water intake. Lack of water during the day, combined with physical activity, can lead to persistent dry mouth and reduced saliva secretion, which plays a key role in pH stabilization, digestion, and tooth protection. Before training, 80 students (66.1%) consume 1–2 glasses of water, 24 (19.8%) 3–4 glasses, 19 (15.7%) more than four glasses, while 8 students (6.6%) do not drink water at all—posing a particular risk, as not drinking before exercise can accelerate dehydration. During training, 46 students (38%) drink 1–2 glasses, 37 (30.6%) 3–4 glasses, and 26 (21.5%) more than four glasses, while 12 (9.9%) do not drink at all, representing the riskiest pattern given the duration of most students' training. After training, all participants drink water, with 51 students (42.1%) consuming 1–2 glasses, 52 (43%) 3–4 glasses, and 18 (14.8%) more than four glasses, indicating that students most often compensate for lost fluids after, rather than during, exercise.

Habits regarding sports and sugary drinks further influence oral health. Sports drinks are not used by 66 students (54.5%), 35 (28.9%) use them rarely, 14 (11.6%) frequently, and 6 (5%) always, meaning that

16.6% of participants regularly consume beverages with low pH, high sugar content, and acids, contributing to enamel erosion and increased caries risk. Juices and carbonated drinks show a similar pattern: 88 students (72.7%) do not consume them, 28 (23.1%) occasionally, and 5 (4.1%) frequently. While positive from a preventive standpoint, this still indicates that a portion of the population consumes highly acidic drinks during increased physical activity and dehydration, raising erosive potential. Dry mouth is never experienced by 11 participants (9.1%), rarely by 56 (46.3%), sometimes by 39 (32.2%), often by 10 (8.3%), and always by 5 (4.1%), meaning that a total of 54 students (44.6%) experience dry mouth at least occasionally—a significant predisposing factor for diseases of hard and soft oral tissues.

Regarding hygiene habits, 52 students (43%) brush their teeth twice daily, and 69 (57%) three or more times, which represents a positive trend. However, 54 students (44.6%) do not use any additional oral hygiene tools, such as floss, interdental brushes, or mouth rinses, while 42 (34.7%) use them occasionally and 25 (20.7%) regularly, indicating room for improvement in preventive habits. In the past year, 90 students (74.4%) had no oral problems, 22 (18.2%) experienced caries, 6 (5%) had gum inflammation, and 3 (2.5%) had both, meaning that 25.6% of participants faced oral issues despite relatively frequent tooth brushing. Most students, 68 (56.2%), recognize the impact of hydration on oral health, 46 (38%) believe it has a partial effect, and only 7 (5.8%) think hydration has no role, indicating a solid level of awareness, although practice does not always reflect knowledge.

According to students, the most common challenges in maintaining oral health are the consumption of sweet and acidic drinks and insufficient water intake during training (77 students; 63.6%), as well as physical contact during sports activities (44 students; 36.4%). Overall, the findings indicate a clear and multifaceted relationship between hydration, duration and intensity of physical activity, frequency of sports and sugary drink consumption, and the occurrence of oral symptoms and diseases, emphasizing that proper hydration before, during, and after training, avoiding energy and acidic drinks during dehydration, and regular and extended oral hygiene (including interdental care) are key factors in maintaining oral health in young adults.

By applying the χ^2 goodness-of-fit test along with the calculation of Cramer's V as a measure of effect size, it was possible to assess deviations of students' responses from a uniform distribution (Table 2). The results indicate that all questions showed statistically significant deviations ($p < 0.01$), meaning that students exhibited clearly defined patterns in their physical activity, hydration, and oral health habits. Analysis of Cramer's V for the 14 survey questions reveals clear and statistically significant behavioral patterns: moderate effects (Q1, Q5, Q7, Q9, Q12, Q14) indicate that the frequency of physical activity, water intake during training, consumption of sports drinks, dry mouth, use of additional oral hygiene products, and perception of the main challenges to oral health vary among students, suggesting the presence of tendencies but also certain heterogeneity within the population. Question Q6 (water intake after training) shows a moderate-to-strong effect, indicating that most students maintain adequate fluid intake after training, although a smaller portion does not consume enough. Strong effects (Q2, Q4, Q10, Q13) highlight clear and consistent practices regarding training duration, water intake before training, frequency of tooth brushing, and awareness of hydration's impact on oral health. Very strong effects (Q3, Q8, Q11) demonstrate dominant patterns in daily water intake, infrequent consumption of juices and carbonated drinks, and low frequency of cavities or gum inflammation, with χ^2 values exceeding 140 and Cramer's V reaching 0.63. These results confirm that students generally have stable and mutually consistent habits, particularly in key areas related to hydration and oral health, while certain aspects of oral hygiene and dry mouth still vary, suggesting the need for further education and promotion of healthy practices within the student population.

Spearman's rank correlation analysis revealed statistically significant associations between physical activity, hydration habits, and oral health outcomes (Table 3).

Higher daily water intake and water intake during training were negatively correlated with dry mouth ($\rho = -0.41$ and $\rho = -0.48$; $p < 0.01$), while dry mouth was positively correlated with oral problems ($\rho = 0.42$, $p < 0.01$). Frequency and duration of training were positively associated with dry mouth ($\rho = 0.27$ and $\rho = 0.34$; $p < 0.05$). Consumption of sports and sugary/gaseous drinks showed moderate positive correlations with oral problems ($\rho = 0.29$ and $\rho = 0.35$; $p < 0.01$). Higher daily water intake and use of additional oral hygiene products were negatively associated with oral problems ($\rho = -0.30$ and $\rho = -0.31$; $p < 0.01$). Additional analyses indicated positive associations between training duration and sports drink consumption ($\rho = 0.25$; $p < 0.05$), frequency of physical activity and sports drink consumption ($\rho = 0.22$; $p < 0.05$), and a weak negative correlation between dry mouth and use of additional oral hygiene products ($\rho = -0.18$; $p < 0.05$). Perception of hydration impact was weakly positively correlated with water intake during training ($\rho = 0.27$; $p < 0.05$).

Discussion

Promoting proper hydration, reducing the consumption of sugary drinks, and encouraging comprehensive oral hygiene practices are essential for preventing dental caries, enamel erosion, and gum diseases among physically active students. The results of this study indicate a significant association between the frequency of physical activity, hydration habits, and oral health status among students in sports programs. Most participants train regularly: 44.6% train three to four times per week, 23.1% five to six times per week, and 21.5% daily, while only 10.7% engage in minimal physical activity (1–2 times per week). Most training sessions last between 60 and 90 minutes (60.3%), and 15.7% exceed 90 minutes, indicating an increased risk of dehydration, reduced saliva secretion, and enhanced dental erosion, especially when combined with the consumption of acidic and sugary beverages [14,21,31,32]. The importance of adequate hydration is further confirmed by Spearman's rank correlation analysis, which showed a moderate negative correlation between daily water intake and the occurrence of dry mouth, as well as between water intake during training and dry mouth. These findings confirm that students who consume larger amounts of water, particularly during physical activity, experience less pronounced symptoms of oral dryness. Considering the protective role of saliva in maintaining oral pH and enamel integrity, insufficient hydration during training represents a significant risk factor for the development of caries and enamel erosion, particularly among physically active individuals [23].

Ericsson et al. [33] highlight the link between oral health and general health behaviors, which aligns with the findings of this study, where nearly 80% of students are physically active. Such habits are often formed during childhood and adolescence [19,34], while lifestyle changes during the transition to university can lead to neglect of healthy eating, oral hygiene, and physical activity. Furthermore, poor lifestyle habits—including lack of physical activity, smoking, alcohol consumption, and stress—are associated with poor oral hygiene

practices among young people [23,35,36]. Analysis of hydration habits shows that 70.2% of students consume more than four glasses of water daily, while 29.7% consume less. Before training, 6.6% of students do not drink water, and 9.9% do not consume fluids during training, representing a direct risk for reduced saliva volume and dry mouth—a phenomenon observed in 44.6% of students. Insufficient hydration may increase the risk of caries, enamel erosion, and inflammatory gum diseases [32,37]. Spearman correlation analysis confirmed a moderate negative association between daily water intake and dry mouth, as well as between water intake during training and dry mouth. These results emphasize the protective role of adequate hydration, especially during physical activity, in maintaining salivary flow and oral homeostasis.
Six percent of students reported consuming sports drinks, while only 4.1% regularly consume juices or carbonated beverages. Although most students avoid these drinks, their use in the context of physical exertion and potential dehydration can increase the risk of enamel erosion and caries [15,21,24,38,39]. In this study, Spearman rank correlations revealed moderate positive associations between the consumption of sports and sweetened or carbonated beverages and the presence of oral problems, indicating that even limited intake of these drinks may contribute to adverse oral health outcomes, especially under physical stress and dehydration. Healthy habits, physical activity, and good oral hygiene, such as brushing teeth twice daily, are crucial for the prevention of oral diseases [31,40]. The study by [7] emphasizes the role of diet in obesity and dental caries, showing a correlation with BMI and fat accumulation in male students, where low BMI correlates with fewer carious lesions, while high BMI is associated with a greater number of carious lesions. Dry mouth was reported by 44.6% of students, at least occasionally, directly affecting the protection of oral flora and acid neutralization, increasing the risk of fungal infections, caries, and enamel damage [31,32,41]. Furthermore, dry mouth showed a moderate positive correlation with reported oral problems, confirming its role as an important mediating factor linking hydration habits and physical activity with worsening oral health.
Analysis of oral hygiene practices shows that students are generally disciplined—all respondents brush their teeth at least twice daily, and 57% brush three or more times daily, consistent with previous findings [31]. However, only 20.7% use additional oral hygiene aids, indicating room for improvement in preventive practices. The prevalence of caries and gingival inflammation in the previous year was 25.6%, consistent with previous studies among young adults [23,34,40,42]. Spearman correlation analysis further showed a negative association between the use of additional oral hygiene aids and oral problems, highlighting their protective effect beyond tooth brushing alone. A weak negative correlation was also observed between dry mouth and the use of additional hygiene aids, indicating that students experiencing oral discomfort are more likely to apply supplementary preventive measures.
Students' awareness of the impact of hydration on oral health is relatively high: 56.2% believe hydration has a direct effect, while 38% consider the effect partial. This awareness is weakly but statistically positively associated with water intake during training, indicating that students who recognize the importance of hydration more frequently apply appropriate hydration practices during physical activity. As the main challenges for maintaining oral health during physical activity, 63.6% of students reported consumption of sugar- and acid-rich foods and beverages, while 36.4% cited physical contact during sports activities. Education on avoiding high-risk foods and drinks, using protective equipment (e.g., mouthguards), and proper hydration represents key preventive measures [7,23,28,43,44]. Analysis of Cramer's V coefficient confirms stable behavioral patterns among students regarding water intake, oral hygiene, and perception of hydration effects, while certain aspects, such as dry mouth and use of additional oral hygiene aids, are more variable. This suggests that interventions should target risky behaviors, while stable patterns can serve as a foundation for educational programs.
Overall, the results of Spearman correlation analysis complement the χ^2 and Cramer's V analyses, highlighting statistically significant associations between physical activity load, hydration habits, beverage consumption, and oral health outcomes.
These results support the concept of a multidimensional interaction of behavioral factors affecting oral health in physically active students. In a broader context, the findings of this study indicate a multidimensional relationship between physical activity, hydration, and oral health, consistent with previous research emphasizing that athletes, especially younger ones, should integrate proper hydration and oral hygiene into their daily routines [33,36,37].

Conclusion

The study of 121 students shows that most are physically active, with 89.2% exercising three or more times per week and 76% training over 60 minutes per session. High activity increases the need for adequate hydration and directly affects oral health, particularly saliva function, which protects teeth and mucosa. Most students drink more than four glasses of water daily (70.2%), though 29.7% consume insufficient fluids. Notably, 9.9% do not drink during training, and some drink too little before exercise, increasing the risk of dry mouth, reduced saliva flow, caries, and enamel erosion. Sports and sugary drinks are consumed regularly by a smaller portion (16.5% and 4.1%), but even this intake can raise erosion risk.
Oral hygiene is generally good, with all students brushing at least twice daily, but only 20.7% use additional hygiene products. A quarter reported cavities or gum inflammation in the past year, indicating that brushing alone is insufficient. χ^2 goodness-of-fit and Cramer's V analyses showed statistically significant deviations ($p < 0.01$) and highlighted stable, consistent patterns in training, hydration habits, tooth brushing, awareness of hydration, and oral health, though some aspects still require further education. Spearman's rank correlation analysis further demonstrated significant relationships between hydration, physical activity, and oral health outcomes, supporting the importance of these behaviors in maintaining oral health. Overall, proper hydration before, during, and after training, avoiding energy and acidic drinks during dehydration, and enhanced oral hygiene are key to maintaining oral health in young adults. Education and promotion of preventive habits can significantly reduce the risk of caries, enamel erosion, and gum disease.

Study Limitations

The study was conducted on a relatively small and homogeneous sample of 121 students of both genders, involved in physical education and sports in East Sarajevo and Banja Luka, which limits the generalizability of the results to a broader population or to individuals of different age groups, professions, or levels of physical activity. This study was not designed to compare specific sports disciplines. Data were collected via self-reported questionnaires, which may introduce subjective bias and socially desirable responses. The study did not include clinical examinations or objective measures of oral health, such as saliva pH or flow rate,

reducing the precision of conclusions regarding the relationship between hydration and oral health. Furthermore, as a cross-sectional study conducted at a single point in time, it cannot capture long-term effects of physical activity and hydration habits or establish causal relationships. Additionally, other risk factors affecting oral health, such as diet, stress, medication use, genetic predispositions, or chronic illnesses, were not comprehensively considered.

Practical Implications and Directions for Future Research

The results highlight the need for educating this population group about the importance of adequate hydration before, during, and after physical activity, as well as the impact of acidic and sugary drinks on oral health. Promoting extended oral hygiene practices, including the use of interdental brushes, floss, and mouth rinses, can significantly reduce the risk of caries, enamel erosion, and gum disease, especially among students who train regularly and engage in intensive physical activities. Development of preventive programs and guidelines tailored specifically to physical education and sports students is recommended.

Future research should involve larger and more heterogeneous samples of students from different cities and faculties to allow for broader generalization of results. It is also recommended to include objective measures of oral health, such as clinical examinations and assessments of saliva pH and flow, as well as longitudinal monitoring of hydration habits and beverage consumption over an extended period. A longitudinal design would allow a better assessment of causal relationships between physical activity, hydration, and oral health. Considering additional risk factors, such as diet, stress, medication, and chronic diseases, would contribute to a more comprehensive understanding of risks and more effective preventive recommendations for physical education and sports students.

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Table 1. Survey questionnaire about hydration, physical activity and oral health.

Question?	Options	N (%)
1. How many times per week do you engage in physical activity?	1–2	13 (10.7)
	3–4	54 (44.6)
	5–6	28 (23.1)
	Daily	26 (21.5)
2. How long does an average training session last?	<30 min	0
	30–60 min	29 (24%)
	60–90 min	73 (60.3%)
	>90 min	19 (15.7%)
3. How much water do you drink during the day?	I don't drink	0
	1–2 glasses	8 (6.6%)
	3–4 glasses	28 (23.1%)
	> 4 glasses	85 (70.2%)
4. How much water do you usually drink before training?	I don't drink	8 (6.6%)
	1–2 glasses	80 (66.1%)
	3–4 glasses	24 (19.8%)
	> 4 glasses	19 (15.7%)
5. How much water do you drink during your workout (if you drink any)?	I don't drink	12 (9.9%)
	1–2 glasses	46 (38%)
	3–4 glasses	37 (30.6%)
	> 4 glasses	26 (21.5%)
6. How much water do you drink after your workout?	I don't drink	0
	1–2 glasses	51 (42.1%)
	3–4 glasses	52 (43%)
	> 4 glasses	18 (14.8%)
7. Do you consume sports drinks during or after your workout?	No	66 (54.5%)
	Yes, rarely	35 (28.9%)
	Yes, often	14 (11.6%)
	Always	6 (5%)
8. Do you consume juices or carbonated drinks during or after your workout?	No	88 (72.7%)
	Yes, rarely	28 (23.1%)
	Yes, often	5 (4.1%)
	Always	0
9. Do you often feel dryness in your mouth during or after your workout?	Never	11 (9.1%)
	Rarely	56 (46.3%)
	Sometimes	39 (32.2%)
	Often	10 (8.3%)
	Always	5 (4.1%)
10. How often do you brush your teeth daily?	Once	0
	Twice	52 (43%)
	Three times or more	69 (57%)
11. Have you had cavities or gum inflammation in the past year?	No	90 (74.4%)
	Yes, cavities	22 (18.2)
	Yes, Gum inflammation	6 (5%)
	Yes, both	3 (2.5%)

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12. Do you use any additional oral hygiene products?	No	54 (44.6%)
	Yes, occasionally	42 (34.7%)
	Yes, regularly	25 (20.7%)
13. Do you believe that adequate hydration affects your oral health?	No	7 (5.8%)
	Partially	46 (38%)
	Yes	68 56.2)
14. What do you think are the biggest challenges to maintaining oral health during training?	Consuming foods high in sugar, juices, soda, sweets, supplements, reduced water intake during exercise, coffee	77 (63.6%)
	Physical contact	44 (36.4%)

Table 2. Effect size Cramer's V.

No	Question ?	Cramer's V	Effect size
Q1	Frequency of physical activity	0.232	moderate
Q2	training duration	0.405	strong
Q3	Daily intake of water	0.637	very strong
Q4	Water intake before training	0.444	strong
Q5	Water intake during training	0.202	moderate
Q6	Water intake after training	0.308	moderate-strong
Q7	Consumption of sports drinks	0.353	moderate
Q8	Consumption of juices/carbonated drinks	0.657	very strong
Q9	Dry mouth during/after training	0.234	moderate
Q10	Frequency of brushing teeth	0.480	strong
Q11	Caries or gum inflammation in the last year	0.635	very strong
Q12	Using additional oral hygiene products	0.204	moderate
Q13	Perception of the influence of hydration	0.420	strong
Q14	The biggest challenges for oral health	0.275	moderate

Note: Effect size (Cramer's V): 0.10–0.19 – small effect; 0.20–0.39 – moderate effect; 0.40–0.59 – strong effect; ≥0.60 – very strong effect.

Table 3. Spearman's rank correlations between physical activity, hydration and oral health variables.

Variable 1 (Question)	Variable 2 (Question)	Spearman's ρ	p-value
Daily water intake (Q3)	Dry mouth (Q9)	−0.41	<0.01
Water intake during training (Q5)	Dry mouth (Q9)	−0.48	<0.001
Dry mouth (Q9)	Oral problems (Q11)	0.42	<0.01
Training duration (Q2)	Dry mouth (Q9)	0.34	<0.05
Frequency of physical activity (Q1)	Dry mouth (Q9)	0.27	<0.05
Sports drink consumption (Q7)	Oral problems* (Q11)	0.29	<0.01
Sugary/carbonated drink consumption (Q8)	Oral problems* (Q11)	0.35	<0.01
Daily water intake (Q3)	Oral problems* (Q11)	−0.30	<0.01
Use of additional oral hygiene products (Q12)	Oral problems* (Q11)	−0.31	<0.01
Perception of hydration impact (Q13)	Water intake during training (Q5)	0.27	<0.05
Training duration (Q2)	Sports drink consumption (Q7)	0.25	<0.05

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Frequency of physical activity (Q1)	Sports drink consumption (Q7)	0.22	<0.05
Dry mouth (Q9)	Use of additional oral hygiene products (Q12)	-0.18	<0.05

Note: Oral problems coded ordinally: 0 = none; 1 = caries or gingival inflammation; 2 = both. Spearman's rank correlation coefficient (ρ) used due to ordinal nature of variables. Significance set at $p < 0.05$.