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The Association Between Sports Nutrition and Hard Dental Tissue Disorders in Athletes: A Systematic Review

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Abstract

Sports nutrition constitutes an essential component of athletic performance optimization; however, its specific dietary characteristics may adversely affect oral health. Frequent consumption of fermentable carbohydrates, acidic beverages, isotonic drinks, energy drinks, and carbohydrate supplements may contribute to the development of dental caries and enamel erosion among athletes. The aim of this systematic review was to evaluate the relationship between sports nutrition and the occurrence of dental hard tissue disorders, with particular emphasis on caries and enamel erosion in physically active populations.

A systematic analysis of the available literature was conducted, including observational, cross-sectional, experimental studies, as well as systematic reviews and meta-analyses published predominantly after 2015. The reviewed evidence involved both amateur and professional athletes across various sports disciplines. Particular attention was given to dietary exposure, consumption patterns of sports products, and modifying factors affecting oral health outcomes. The findings indicate that athletes may represent a population at increased risk of dental caries and enamel erosion, particularly in the context of frequent intake of acidic and sugar-rich sports products. Isotonic beverages, energy drinks, and carbohydrate supplements demonstrate potential cariogenic and erosive properties due to their low pH and fermentable carbohydrate content. However, the available evidence remains heterogeneous and inconclusive, as the observed associations appear to be significantly influenced by salivary flow, hydration status, fluoride exposure, oral hygiene practices, and remineralization capacity.

Sports nutrition should therefore be considered a potential modifying factor in the development of oral diseases rather than an isolated causative determinant. Preventive strategies, athlete education, and interdisciplinary collaboration between dentists, sports physicians, and dietitians may play a critical role in minimizing oral health risks among athletes. Further longitudinal and interventional studies are required to clarify causal relationships and optimize preventive recommendations.

Methodology. Studies included in this systematic review were primarily published after 2015 and comprised cross-sectional analyses, observational studies, as well as systematic reviews

and meta-analyses investigating the impact of sports nutrition on oral health. The number of studies analyzed within individual reviews varied considerably, ranging from several to several dozen publications, depending on the applied inclusion criteria. For example, in a review assessing the impact of sports drinks on enamel erosion, over 1,300 publications were screened during the initial selection stage, of which only a small proportion met the final quality criteria (1).

The included studies originated from various regions worldwide, including Europe, South America, and Asia, enhancing their population representativeness. The analyzed populations comprised both amateur and professional athletes representing diverse sports disciplines, such as running, swimming, endurance sports, and mixed disciplines. An example is a cross-sectional study conducted in Brazil, which evaluated 108 runners in terms of enamel erosion risk factors and dietary habits (2).

From a methodological perspective, cross-sectional and observational studies predominated, enabling the assessment of the prevalence of dental caries and enamel erosion in athletic populations. In one study conducted in Portugal between 2023 and 2024, involving 80 athletes, a high prevalence of dental caries (50%) and enamel erosion (40%) was reported (3). While such studies allow for an estimation of the scale of the problem, their limitation lies in the inability to establish clear causal relationships.

The analysis also incorporated systematic reviews and meta-analyses, which provide a synthesized evaluation of available evidence. One such study demonstrated that physically active individuals who regularly consume sports drinks have more than a 2.5-fold increased risk of developing erosive lesions (4). However, other reviews did not confirm a clear association between isotonic drink consumption and enamel erosion, highlighting significant heterogeneity of findings and methodological limitations among the analyzed studies (1).

A portion of the included studies had an experimental design, including in vitro investigations focusing on the erosive potential of specific products, such as energy drinks. These studies indicate that low pH values—often ranging from approximately 2.5 to 3.5—combined with high sugar content may significantly contribute to enamel demineralization (5). Although experimental studies allow for the assessment of chemical properties of products, they do not fully replicate intraoral conditions, where saliva, biofilm, exposure time, and individual hygiene behaviors play a critical role.

In this review, a qualitative synthesis of findings was conducted. A quantitative meta-analysis was not performed due to substantial heterogeneity in study designs, populations, diagnostic methods, and approaches to assessing dietary exposure. The included studies differed in terms of inclusion criteria, sample size, type of physical activity assessed, methods of measuring sports drink consumption, and definitions of enamel erosion and dental caries. Therefore, direct comparison of results requires caution.

The clinical relevance of the discussed issue is further supported by epidemiological data. According to the literature, the prevalence of dental caries among athletes ranges from 20% to 84%, while enamel erosion ranges from 42% to 59% (6). Authors emphasize that sports nutrition, characterized by high sugar intake and frequent consumption of acidic beverages, may constitute a significant risk factor for oral health. These findings highlight the need for further research, particularly longitudinal and interventional studies, which would allow for a more precise assessment of the impact of individual components of sports nutrition on hard dental tissues.

Keywords: sports nutrition, dental caries, enamel erosion, oral health, isotonic drinks, energy drinks

1. Introduction

In recent decades, there has been a dynamic increase in interest in physical activity, recreational sports, and competitive athletics. This trend is associated with the growing importance of well-planned nutrition, supplementation strategies, and recovery-supporting protocols. Contemporary approaches to athletic preparation focus not only on training itself but also on optimizing the intake of nutrients and fluids to enhance physical performance, maintain metabolic balance, and reduce the risk of physiological overload.

Sports nutrition is therefore a fundamental component of the training process and may influence both athletic performance and overall health status. At the same time, an increasing body of evidence suggests that certain aspects of sports nutrition may have adverse effects on oral health, particularly in relation to the development of dental caries and enamel erosion. A high prevalence of oral diseases among athletes has been widely documented in the literature, highlighting the significance of this issue in the fields of sports medicine and dentistry (6) (7). This issue is particularly important because oral health may affect not only quality of life, but also the ability to train regularly, recovery processes, sleep quality, and overall physical condition. A characteristic feature of sports nutrition is the frequent consumption of products rich in easily digestible carbohydrates, including isotonic drinks, energy drinks, energy gels, and other carbohydrate supplements. These products are used to maintain adequate hydration, replenish electrolytes, and provide energy during physical exertion (8). Their use is particularly widespread in endurance sports, where prolonged physical effort requires a continuous supply of carbohydrates during training or competition. From the perspective of exercise physiology, these products may be beneficial; however, from the standpoint of oral health, their frequent consumption may constitute a risk factor. An important concern remains the chemical composition of products used in sports nutrition. Many sports and energy drinks are characterized by a high sugar content and low pH, which may promote enamel demineralization and the development of dental caries (8). Moreover, the frequent intake of such products and their prolonged contact with the tooth surface increase enamel exposure to erosive factors, potentially intensifying damage to hard dental tissues (9). An additional factor affecting oral health in athletes is dehydration associated with intense physical exertion. During training, increased fluid loss through sweating occurs, and insufficient fluid intake may lead to reduced salivary flow and impaired protective functions (10). Saliva plays a crucial role in neutralizing acids, removing food debris, and supplying ions necessary for enamel remineralization. Therefore, reduced salivary flow may increase enamel susceptibility to acidic products and promote the development of both erosion and caries. Consequently, athletes are particularly exposed to erosive factors due to the frequent consumption of acidic beverages and the specific nature of physical exertion (1). The process of enamel erosion is closely related to the chemical properties of consumed beverages, especially their pH, which plays a key role in initiating demineralization processes. Prolonged exposure of enamel to acids may lead to permanent

structural changes, including reduced enamel microhardness and the formation of irreversible defects (4).

Despite the growing number of studies on oral health in athletes, the available data remain inconclusive. The literature emphasizes substantial heterogeneity of results due to methodological differences between studies, which complicates direct comparisons (9). Some studies indicate a significant association between the consumption of sports drinks and enamel damage, while others do not confirm such a relationship, making interpretation difficult and limiting the ability to draw clear clinical conclusions (2) .

At the same time, available evidence suggests that athletes may represent a group at increased risk of developing oral diseases due to the interaction of dietary, physiological, and behavioral factors (1). An additional issue is the lack of standardization both in assessing exposure to sports nutrition and in diagnosing dental caries and enamel erosion, which limits the comparability of studies (9). The impact of sports nutrition on oral health is multifactorial and depends, among other factors, on the composition of consumed products, frequency of intake, duration of exposure, and individual characteristics such as salivary secretion (4). Despite numerous individual studies, there is still a lack of comprehensive analyses synthesizing available data in a systematic manner, which justifies the need for a systematic review in this area (6).

The aim of this study is therefore to systematically assess the impact of sports nutrition on the development of dental caries and enamel erosion in athletes, with particular emphasis on the role of isotonic drinks, energy drinks, and dietary supplements (11). The specific objectives include identifying the most common dietary patterns among athletes, evaluating their potential impact on oral health, and analyzing factors modifying the risk of developing caries and enamel erosion (3). Additionally, the study aims to assess the consistency of available scientific evidence and identify research gaps that require further investigation in future studies (1).

2. Enamel Erosion – Definition and Characteristics of the Phenomenon

Dental erosion is defined as the chemical loss of mineralized tooth tissues caused by acids not associated with the activity of bacteria present in dental plaque. In contrast to dental caries, where the demineralization process results from bacterial metabolism of carbohydrates, erosion is primarily driven by the direct action of acids of either extrinsic or intrinsic origin. Exogenous

sources mainly include acidic foods and beverages, whereas endogenous factors involve gastric acid, as observed in conditions such as gastroesophageal reflux disease or eating disorders (12) (13) (14).

According to current knowledge, enamel erosion is a progressive and irreversible process. In its early stages, superficial demineralization of enamel occurs, accompanied by a reduction in microhardness and increased susceptibility to further damage. As the condition progresses, it may extend into dentin, leading to hypersensitivity, alterations in tooth crown morphology, compromised esthetics, and impaired masticatory function (13) (12) (15).

It is important to distinguish between erosion and the broader concept of erosive tooth wear (ETW). This term encompasses the loss of dental hard tissues resulting from the combined action of chemical and mechanical factors, such as abrasion and attrition. In practice, this means that acidic conditions weaken enamel structure, after which mechanical forces—such as toothbrushing or occlusal contact—further accelerate tissue loss (15) (16).

The mechanism of erosion involves the dissolution of hydroxyapatite crystals under acidic conditions. Key determinants include both the pH level and titratable acidity, which reflects a substance's capacity to maintain an acidic environment over time. The lower the pH and the longer the duration of acid exposure, the greater the risk of enamel demineralization. For this reason, sports drinks, energy drinks, and other acidic products commonly used in sports nutrition are considered significant risk factors for enamel erosion (17) (6) (18) .

Contemporary research indicates that enamel erosion is a multifactorial process. Exposure to acids alone does not always result in clinically significant damage, as the progression of erosion depends on additional factors, including salivary properties, buffering capacity, flow rate, duration of exposure, and frequency of acidic product consumption. Oral hygiene habits also play an important role. Therefore, in physically active individuals—who often experience dehydration, reduced salivary flow, and frequent consumption of acidic beverages—the risk of developing erosion may be significantly increased (6,13).

From a clinical perspective, enamel erosion may remain asymptomatic for an extended period, making early detection difficult. Initial signs include smoothing of the enamel surface, loss of its natural microtexture, and a matte appearance. In more advanced stages, thinning of hard

tissues, increased translucency of incisal edges, rounding of cusps, and—following dentin exposure—hypersensitivity may occur. Consequently, enamel erosion is currently recognized as a significant oral health concern, particularly in populations exposed to frequent dietary acids (13) (12) (19).

In summary, enamel erosion is a non-bacterial, chemical, and irreversible loss of dental hard tissues caused by acids of either extrinsic or intrinsic origin. Due to its chronic and multifactorial nature, it represents a significant challenge in both conservative dentistry and sports medicine, with its relevance increasing alongside the growing consumption of acidic beverages and supplements in sports nutrition.

3. Dental Caries – Definition and Mechanisms of Development

Dental caries is one of the most prevalent chronic diseases of multifactorial origin and leads to the gradual demineralization of hard dental tissues. Its development results from an imbalance between demineralization and remineralization processes occurring in the oral environment (20–22). A key role in the pathogenesis of the disease is played by the bacterial biofilm, in which microorganisms metabolize fermentable carbohydrates, leading to the production of organic acids. These acids lower the pH within dental plaque, initiating the dissolution of enamel minerals (21,23,24). An important factor influencing the development of caries is not only the total amount of sugar consumed but, more importantly, the frequency of its intake. Repeated exposure to fermentable carbohydrates promotes the persistence of an acidic environment in the oral cavity, thereby enhancing demineralization and contributing to the progression of carious lesions.

The caries process is dynamic and, in its early stages, may be reversible if the balance between demineralization and remineralization is restored. Under physiological conditions, saliva plays a crucial role in this mechanism by neutralizing acids and supplying calcium and phosphate ions necessary for enamel repair (25).

When demineralization predominates over a prolonged period, irreversible cavitated lesions develop. This is a consequence of sustained acid exposure and insufficient effectiveness of the body's protective mechanisms.

Contemporary understanding conceptualizes dental caries as a diet-dependent biofilm-mediated disease, in which key interactions occur between microorganisms, dietary components, and host-related factors.

4. Sports Nutrition – Characteristics

Sports nutrition plays a crucial role in maintaining physical performance and optimizing recovery; however, its specific components—particularly the frequent consumption of sugar-rich and low-pH products—may significantly impact oral health. The studies analyzed most commonly evaluated three main categories of products: isotonic drinks, energy drinks, and carbohydrate gels and supplements. Additionally, it should be emphasized that sports nutrition is often associated with irregular eating patterns and frequent snacking, which may disrupt the balance within the oral environment (26).

4.1 Isotonic Drinks

Isotonic drinks are among the most commonly consumed products by athletes, especially in endurance sports. Their primary function is the rapid replenishment of fluids, electrolytes, and energy through the provision of easily absorbable carbohydrates. The sugar content of these beverages typically ranges from 6% to 8%, while their pH usually falls between 3.0 and 4.0, classifying them as products with erosive potential.

Studies indicate that regular consumption of isotonic drinks, particularly during exercise, results in prolonged exposure of enamel to acids. Moreover, the pattern of consumption—frequent intake of small amounts—may further increase the risk of demineralization. Systematic reviews emphasize that the acidic nature and the presence of fermentable carbohydrates in isotonic drinks may contribute to both enamel erosion and the development of dental caries (1).

At the same time, their impact is not unequivocal and depends on various factors, including duration of exposure, salivary flow, and oral hygiene practices (2) (26).

4.2 Energy Drinks

Energy drinks represent a distinct category of products, commonly consumed by both athletes and physically active individuals. Compared to isotonic drinks, they contain higher

concentrations of caffeine, taurine, and sugars, and their pH may be even lower, sometimes falling below 3.0.

Experimental studies indicate that energy drinks exhibit a high erosive potential, mainly due to the presence of organic acids such as citric acid (5). At the same time, their high content of simple sugars promotes the growth of cariogenic bacteria, thereby increasing the risk of dental caries. Epidemiological studies suggest that individuals who regularly consume energy drinks may present a higher prevalence of enamel damage and carious lesions.

4.3 Carbohydrate Gels and Supplements

Energy gels and carbohydrate supplements are widely used during prolonged physical activity, particularly in endurance sports such as long-distance running or triathlon. These products contain high concentrations of simple sugars, such as glucose, fructose, and maltodextrins, enabling rapid energy delivery (27) (28). Due to their viscous consistency, gels may adhere to the tooth surface for extended periods, promoting bacterial fermentation and acid production. Additionally, they are often consumed in conditions with limited access to oral hygiene, which increases their cariogenic potential. The presence of flavoring agents and acids may further enhance their erosive effects.

5. Impact of Diet on Dental Caries

The influence of sports nutrition on the development of dental caries has been widely investigated; however, the available evidence remains inconclusive. Most studies suggest that increased intake of fermentable carbohydrates, characteristic of athletes' diets, may promote the development of carious lesions. Of particular importance is the frequent exposure of teeth to sugars, combined with reduced salivary activity during intense physical exertion, which favors the persistence of an environment conducive to demineralization.

6. Prevalence of Dental Caries

Available data indicate a relatively high prevalence of dental caries among athletes. In a review focusing on oral health in physically active individuals, the proportion of athletes affected by caries was estimated to range from 20% to 84%, reflecting considerable heterogeneity due to methodological and population differences (6).

These observations are supported by primary studies. In a cross-sectional study conducted in Portugal between 2023 and 2024, approximately 50% of athletes were diagnosed with dental caries, indicating that this issue is common even among young and physically active populations (3).

Some studies further suggest that elite athletes may exhibit higher caries rates compared to the general population, which is associated with specific dietary habits, including frequent consumption of carbohydrate-rich products during training and competition.

7. Role of Sugar Intake and Consumption Frequency

A key factor in the pathogenesis of dental caries is not only the total quantity of sugar consumed but, more importantly, the frequency of intake. Sports nutrition often involves the regular consumption of small portions of energy sources, such as isotonic drinks or carbohydrate gels, leading to repeated exposure of enamel to sugars throughout the day. This pattern promotes the persistence of an acidic oral environment and increased activity of cariogenic bacteria (1).

Furthermore, products used in sports nutrition typically contain highly fermentable carbohydrates, such as glucose, sucrose, and maltodextrins, which are rapidly metabolized by plaque bacteria, resulting in acid production and enamel demineralization. The mode of consumption is also significant. Frequent sipping of isotonic drinks has been shown to prolong the contact time between teeth and sugars and acids, thereby increasing the risk of caries development (4).

At the same time, it should be emphasized that the presence of sugars in the diet does not inevitably lead to caries development. This effect may be significantly modified by protective factors such as proper oral hygiene, adequate salivary flow, and fluoride exposure. This highlights the multifactorial nature of dental caries and the need to consider individual risk factors in its assessment.

In summary, dental caries is a common issue among athletes, although its prevalence varies. The frequency of sugar intake, characteristic of sports nutrition, plays a key role in maintaining conditions favorable for enamel demineralization. However, this effect remains dependent on individual factors, which may partly explain the inconsistency of findings reported in the literature (26).

8. Modifying Factors

The impact of sports nutrition on the development of dental caries and enamel erosion is not unequivocal and depends on a range of modifying factors. The literature particularly emphasizes the role of saliva, hydration status, oral hygiene practices, and protective factors such as fluoride and the capacity for remineralization of dental hard tissues.

8.1 Saliva

One of the most important modifying factors influencing the effect of sports nutrition on oral health is saliva, particularly its quantity and buffering capacity. Adequate salivary flow enables dilution of dietary acids, reduces their contact time with tooth surfaces, and supports the maintenance of mineral balance in the oral environment. In practice, this means that even with similar exposure to cariogenic and erosive products, the risk of enamel damage may vary depending on salivary gland function and secretion rate (25,29).

8.2 Dehydration

Dehydration associated with intense physical activity may amplify the negative effects of sports nutrition on dental hard tissues. Reduced salivary secretion leads to impaired protective functions, resulting in prolonged acid exposure and decreased ability to neutralize the oral environment and clear food residues. Consequently, products rich in sugars and with low pH may exert stronger and longer-lasting effects on enamel. Therefore, hydration status should be considered a significant risk factor when analyzing the relationship between sports nutrition and the development of dental caries and enamel erosion (10) (6).

8.3 Oral Hygiene

Oral hygiene plays a particularly important role in athletes, whose frequent intake of carbohydrate-rich products during physical activity increases cariogenic load. Inadequate hygiene practices prolong the contact of sugars and acids with the bacterial biofilm, thereby promoting the development of carious lesions. Conversely, proper oral hygiene may partially mitigate the risks associated with sports nutrition and should therefore be considered a key modifying factor in the interpretation of study findings (30).

8.4 Protective Role of Fluoride

Fluoride remains one of the most important factors limiting the impact of sports nutrition on enamel demineralization and caries development. Its role encompasses both home-based preventive measures and professional interventions in high-risk individuals. In athletes who frequently consume acidic and sugar-rich products, regular fluoride exposure may serve as a crucial protective factor, reducing the adverse effects of diet (31) (32).

8.5 Remineralization

The process of remineralization plays a key role in mitigating the effects of frequent exposure of enamel to acids and fermentable carbohydrates present in sports nutrition. Effective repair of early enamel damage requires the availability of calcium, phosphate, and fluoride ions in the oral environment (25). However, the capacity for remineralization depends not only on diet but also on saliva quality and the presence of factors supporting enamel reconstruction. In athletes, this mechanism may have particular protective significance; however, its effectiveness is reduced under conditions of frequent exposure to acidic beverages, dehydration, and inadequate oral hygiene (25) (33,34).

9. Clinical Implications

The findings of this review have important practical implications for dentistry, sports medicine, and sports nutrition. Athletes, particularly those engaged in endurance disciplines, should be considered a population at potentially increased risk of developing dental caries and enamel erosion. This does not imply the need for complete elimination of sports products, but rather highlights the importance of their rational use and the implementation of appropriate preventive measures.

9.1 Athlete Education

Athlete education is a key component of oral disease prevention, particularly in the context of specific dietary and training demands. Despite a generally high awareness of overall health, knowledge regarding the impact of diet and nutritional habits on oral health often remains insufficient (6).

Of particular importance is education on the consequences of frequent consumption of carbohydrate-rich products, such as isotonic drinks and energy supplements, which may contribute to the development of caries and enamel erosion. Preventive education should also promote proper oral hygiene practices and strategies to reduce enamel damage, such as rinsing the mouth with water after consuming sports drinks, using fluoride-based products, and appropriate meal planning (7).

Educational programs should be integrated into the training process, involving coaches, dietitians, and medical staff. Such an approach enhances the effectiveness of promoting health-oriented behaviors among athletes (35)

9.2 Role of the Sports Dentist

A sports dentist plays a crucial role in the comprehensive care of athletes, encompassing preventive, diagnostic, and therapeutic measures related to oral diseases. Their responsibilities extend beyond the treatment of existing conditions and include identification of risk factors and implementation of preventive strategies (36). A key aspect of dental care in sports is the early detection of carious and erosive lesions, allowing for timely preventive and therapeutic interventions. Therefore, regular dental check-ups should be a standard component of athletes' healthcare.

An important function of the sports dentist is also educational, involving support for athletes in modifying dietary habits, improving oral hygiene, and using preventive measures such as fluoride products. Individualized recommendations enable adaptation to the specific demands of a given sport and the athlete's lifestyle.

Effective care requires interdisciplinary collaboration between the dentist, sports physician, and dietitian. This approach allows for a comprehensive assessment of the athlete's health and the implementation of coherent and effective preventive strategies (37).

10. Practical Preventive Strategies

Practical measures to reduce the risk of dental caries and enamel erosion in athletes include controlling the frequency of consumption of acidic and sugar-rich products, selecting products with lower erosive potential, rinsing the mouth with water after consuming sports drinks,

avoiding tooth brushing immediately after acid exposure, and regular use of fluoride toothpaste. Maintaining proper hydration is also essential, as adequate salivary flow is one of the primary protective mechanisms.

For high-risk athletes, an individualized preventive plan should be considered, including more frequent dental check-ups, professional fluoride applications, dietary assessment, and monitoring of early signs of enamel erosion. Such an approach may limit the progression of irreversible damage to dental hard tissues and improve long-term oral health outcomes.

11. Limitations of the Reviewed Studies

The analysis of available studies reveals several important limitations that must be considered when interpreting the results. Most studies are cross-sectional or observational in nature, which limits the ability to establish causal relationships between sports nutrition and the development of dental caries and enamel erosion. While cross-sectional studies allow for the assessment of disease prevalence, they do not determine whether dietary exposure preceded the development of lesions.

Another significant issue is the lack of standardization in the assessment of both dietary exposure and oral health status. Different studies use varying diagnostic criteria and assessment tools, making direct comparison difficult. This applies to the evaluation of both enamel erosion and caries, as well as methods of recording consumption of sports drinks, energy gels, and carbohydrate supplements.

Many analyses also fail to account for important confounding factors, such as oral hygiene, fluoride use, dietary habits unrelated to sports, or individual salivary characteristics. This may lead to overestimation or underestimation of the actual impact of sports nutrition. For example, an athlete who regularly consumes isotonic drinks but maintains excellent oral hygiene and uses fluoride prophylaxis may have a lower risk than someone with similar consumption but without protective measures.

An additional limitation is the scarcity of longitudinal studies that would allow assessment of the long-term effects of sports nutrition on oral health. There is also a lack of interventional studies evaluating the effectiveness of specific preventive strategies, such as modification of sports drink composition, use of fluoride rinses, or oral health-focused nutritional education.

Many studies involve relatively small sample sizes or focus on specific athletic populations, limiting the generalizability of findings. It should also be noted that some studies are experimental in vitro. While useful for assessing the erosive potential of products, they do not fully replicate clinical conditions, where saliva, biofilm, variable exposure time, and hygiene behaviors play crucial roles. Therefore, laboratory findings should be interpreted alongside clinical and epidemiological data.

12. Discussion

The findings of this review indicate that sports nutrition may contribute to an increased risk of dental caries and enamel erosion, particularly when it involves frequent consumption of fermentable carbohydrates and acidic beverages. However, this relationship is complex and cannot be interpreted solely on the basis of dietary exposure. The development of oral diseases in athletes depends on the interaction of multiple factors, including salivary flow, hydration status, oral hygiene practices, fluoride exposure, and the frequency and duration of contact between dietary acids or sugars and the tooth surface.

The available evidence suggests that athletes, especially those involved in endurance sports, may represent a population requiring targeted preventive strategies. Sports drinks, energy drinks, and carbohydrate supplements can be beneficial for performance and recovery, but their repeated use during training and competition may create conditions favorable for enamel demineralization. Therefore, preventive recommendations should not focus on complete elimination of these products, but rather on rational use, risk assessment, and protective measures.

A major limitation of the current evidence is the heterogeneity of study designs, diagnostic criteria, and methods used to assess dietary exposure. This limits the possibility of drawing definitive causal conclusions. Future studies should include longitudinal and interventional designs to better determine the long-term effects of sports nutrition on oral health.

Overall, the results emphasize the need for interdisciplinary cooperation between dentists, sports physicians, dietitians, coaches, and athletes. Integrating oral health education into sports care may help reduce the risk of caries and erosion while maintaining the nutritional strategies necessary for athletic performance.

13. Conclusion

Sports nutrition may represent a significant risk factor for the development of dental caries and enamel erosion, primarily due to frequent consumption of products rich in fermentable carbohydrates and low-pH beverages. Particular importance is attributed to isotonic drinks, energy drinks, and carbohydrate gels and supplements, which may contribute both to bacterial acid production and direct chemical demineralization of enamel. The risk is especially elevated when these products are consumed frequently, in small amounts, and over prolonged periods.

At the same time, the impact of sports nutrition on oral health is multifactorial and depends on individual and environmental factors such as salivary flow, hydration status, oral hygiene, fluoride use, and remineralization capacity. Therefore, it cannot be conclusively stated that sports nutrition alone leads to caries or enamel erosion in every athlete; however, it may increase the risk, particularly in the presence of additional unfavorable factors.

Education of athletes and interdisciplinary care involving collaboration between dentists, sports physicians, dietitians, and coaches play a crucial role in prevention. Preventive strategies should include individualized risk assessment, rational use of sports products, adequate hydration, consistent oral hygiene, fluoride use, and regular dental check-ups.

Further high-quality research is necessary, particularly longitudinal and interventional studies, to better clarify causal relationships between sports nutrition and oral health. Future research should also consider differences between sports disciplines, levels of athletic performance, supplementation strategies, and individual protective factors. This will enable the development of more precise, tailored preventive recommendations for athletes.

Disclosure

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