Regular Physical Activity and Dental Erosion: A Systematic Review

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Abstract: Dental erosion is the irreversible pathological loss of hard tissues, which are chemically dissolved by acids, especially through external means, such as diet (e.g., fruit juices, isotonic or energy drinks). This systematic review was designed to answer the question “Is there a relationship between dental erosion and regular physical activity with or without sports drink consumption?” Following the inclusion and exclusion criteria, sixteen studies were included in this systematic review (according to PRISMA statement guidelines). Based on the meta-analysis, physically active individuals who declared regular consumption of sports drinks had a more than 2.5-fold increase in the odds of erosive lesions. In general, nearly half of the people who practiced sports experienced tooth erosion, and more than half frequently consumed sports beverages. Despite the heterogeneity of the included studies (different age groups, various sports disciplines), regular physical activity was associated with an increased risk of dental erosion, especially under the influence of frequent consumption of sports drinks.

Keywords: dental erosion; erosive lesion; physical activity; sports professional; swimming; amateur athlete; sports drinks; isotonic beverages

1. Introduction

Dental erosion is the irreversible pathological loss of enamel and dentine, which are chemically dissolved by acids with an exogenous or endogenous origin, not those produced by oral bacteria [1,2]. Tooth erosion is a condition with a multifactorial aetiology that includes chemical, biological, and behavioural factors. The erosive potential of acidic beverages depends on their chemical properties, such as the pH, titratable acidity, mineral content, adherence to the tooth surface or calcium chelation. Examples of biological factors are the salivary flow rate, acquired pellicle, and tooth structure and relation to cheeks or tongue. Moreover, behavioural factors, such as dietary habits, regular physical activity resulting in dehydration and decreased salivary flow, excessive oral hygiene, or, on the other hand, chronic addictions (e.g., alcoholism), may predispose individuals to dental erosion [3]. Sources of acid delivery to the oral cavity can be divided into two groups: intrinsic and extrinsic. Among intrinsic factors there are vomiting in anorexia or bulimia, gastroesophageal reflux, or other chronic gastrointestinal disorders. Extrinsic acids come from external means, such as diet (e.g., acidic beverages: fruit juices, isotonic or energy drinks, wine), chronic consumption of selected medication, or the occupational environment [4,5].

It can be challenging to detect initial erosion lesions because they may be imperceptible. The erosive process is much faster than caries, as frequent exposure to acids leads to permanent hard tissue loss with accompanying hypersensitivity. During the oral
examination, erosion defects have a characteristic appearance—a smooth glazed enamel surface [6,7]. The fundamental principle of treatment is the reduction of acid exposure and the enhancement of remineralisation [8]. The basic prevention is mainly based on limiting the frequency of consuming low pH products [9]. Patients should also take care of their oral hygiene by using low abrasive pastes and regular application of preparations containing fluoride or casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) [10–12]. Moreover, tooth brushing immediately after the enamel’s exposure to acidic drinks must be avoided in order to enable pH neutralisation of the oral environment and not cause more considerable losses through the mechanical action [13,14].

Physically active consumers are generally not aware of the erosive potential of sports drinks. These beverages have a low pH value and contain citric acid as an ingredient, which is an organic acid provoking a drop in salivary pH [15]. Citric acid might also induce the process of chelation, which is the dissolution of calcium ions from the structure of enamel [16]. Both of these factors play a significant role in the process of erosion. Most sports drinks’ pH values are contained within the range from 3.16 to 3.70 [17]. Although critical pH value for enamel, depending on ontogenetic tendencies, oscillate between 5.5 to 6.5 [18]. This leads to the conclusion that beverages with a pH value below 5.5 can have an adverse effect on enamel and dentine. Other aspects influenced by ontogenetic predispositions are the quantity and quality of saliva as well as the resilience of the enamel. Saliva has protective values against acids causing dental erosion [19]. Therefore, athletes with any deficits of quality or quantity of saliva may be at higher risk of dental erosion. The common consumption of sports drinks might cause a reduction in the microhardness of enamel and lead to irreversible erosive lesions [15]. The level of lesions depends on the frequency of consumption and the length of time the beverage is kept in the mouth [20]. Frequent intake of isotonic drinks might cause sensitivity, loss of dental structure, and dentine exposure. Studies showed that the temperature of consumed sports drinks influences their erosive potential. In order to reduce the damaging effects on the dental tissues, it is recommended to intake those beverages at 9 °C instead of consuming them at room temperature [15,21].

Nowadays, regular physical exercises and the consumption of sports drinks are becoming increasingly common. However, those who practice these activities are unaware of the potential risks of negative health consequences, including the development of erosive lesions. Therefore, our systematic review was designed in order to answer the question “Is there a relationship between dental erosion and regular physical activity with or without sports drinks consumption?”, formulated according to the PICO (population, intervention, comparison, outcome) process.

2. Materials and Methods
2.1. Search Strategy and Data Extraction

A systematic review was conducted up to 20 November 2021, according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines [22], using the databases PubMed, Scopus, and Web of Science. The search formulas included:

- For PubMed: ((dental erosion) OR (tooth erosion) OR (erosi* lesion)) AND ((sport* professional) OR (physical activity) OR (sport*) OR (athlet*) OR (runner) OR (football*) OR (player) OR (cyclist) OR (swimm*) OR (sport* drink) OR (isotonic*))

- For Scopus: TITLE-ABS-KEY((“dental erosion”) OR (“tooth erosion”) OR (“erosi* lesion”)) AND ((“sport* professional”) OR (“physical activity”) OR (sport*) OR (athlet*) OR (runner) OR (football*) OR (player) OR (cyclist) OR (swimm*) OR (“sport* drink”) OR (“isotonic*”))

- For Web of Science: TS = (dental erosion OR tooth erosion OR erosi* lesion) AND TS = (sport* professional OR physical activity OR sport* OR athlet* OR runner OR football* OR player OR cyclist OR swimm* OR sport* drink OR isotonic*).
Records were screened by title, abstract, and full text by 2 independent investigators. The studies included in this review matched all the predefined criteria according to PICOS (population, intervention, comparison, outcomes, and study design), as shown in Table 1. A detailed search flowchart is presented in the Results section.

Table 1. Inclusion and exclusion criteria according to the PICOS.

| Parameter       | Inclusion Criteria                                                                 | Exclusion Criteria                                                                 |
|-----------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Population      | people practising sport professionally or with regular physical activity—aged from 0 to 99 years, both sexes | people with irregular physical activity; people only drinking sports beverages without declared physical activity |
| Intervention    | not applicable                                                                     | not applicable                                                                      |
| Comparison      |                                                                                     |                                                                                     |
| Outcomes        | determined clinically erosive lesions (prevalence and/or severity)                  | determined only other dental indices                                                |
| Study design    | case-control, cohort and cross-sectional studies published after 2000               | literature reviews, case reports, expert opinion, letters to the editor, conference reports, not published in English |

The results of the meta-analysis are presented in forest plots using MedCalc Statistical Software version 19.5.3 (MedCalc Software Ltd., Ostend, Belgium) and Statistica 13.3 (Statsoft, Cracow, Poland).

2.2. Quality Assessment and Critical Appraisal for the Systematic Review of Included Studies

The risk of bias in each individual study was assessed according to the “Study Quality Assessment Tool” issued by the National Heart, Lung, and Blood Institute within the National Institute of Health [23]. These questionnaires were answered by two independent investigators, and any disagreements were resolved by discussion between them. The summarised quality assessment for every single study is reported in Figure 1. The most frequently encountered risks of bias were the absence of data regarding sample size justification (12 studies), randomisation (14 studies) and blinding (14 studies). However, it should be noted that most of the papers contained information about the calibration of the examiners. The critical appraisal was summarised by adding up the points for each criterion of potential risk (points: 1—low, 0.5—unspecified, 0—high). Eleven studies (68.75%) were classified as having good quality (≥80% total score) and five (31.25%) as intermediate (≥60% total score).

The level of evidence was assessed using the classification of the Oxford Centre for Evidence-Based Medicine levels for diagnosis [24]. All of the included studies have the third or fourth level of evidence (in this 5-graded scale).
3. Results

Following the search criteria, our systematic review included 16 studies, demonstrating data collected in 12 different countries from a total of 2440 participants declaring regular physical activity (including 1429 men, 779 women and 232 intellectually disabled athletes without reported gender). Figure 2 shows the detailed selection strategy of the articles. The inclusion and exclusion criteria are presented in Table 1 (in the Materials and Methods section).

From each eligible study included in the present systematic review, we collected data about its general characteristics, such as the year of publication and setting, involved participants, kind of physical activity, kind of consumed beverages during training, and assessed clinical indices for dental erosion (Table 2). The majority of the studies had complete information about determined parameters. Only three of the included studies had control groups, and the others had cross-sectional study. Five papers focused on a group of professional swimmers and two on triathletes and soccer players. One study concerned participants in the Olympic Games and another one studied participants in the Special Olympics. The other articles described non-homogenous groups of athletes practicing various sport disciplines. In about two-thirds of the studies, participants reported regular consumption of sports drinks. Additionally, Table 3 presents the detailed characteristics considered in the studies: physical activity frequency, sports drink consumption frequency, as well as frequency and severity of erosive lesions. The percentages of the frequency of sports drink consumption and the severity of erosion cavities were recalculated using the athletes’ declaration of consumption of these drinks and demonstration of tooth erosion, respectively.
Figure 2. PRISMA flow diagram presenting search strategy.

Table 2. General characteristics of included studies.

| Author, Year, Setting | Participants (F/M) | Age [Years] | Controls (F/M; Age) | Kind of Physical Activity | Kind of Beverages | Clinical Indices for Erosion |
|-----------------------|-------------------|-------------|---------------------|---------------------------|-------------------|----------------------------|
| Antunes et al., 2017, Brazil [25] | 108 (41/67) | 18–60; mean 34.1 | - | amateur running | sports drinks | dental wear and type according to Eccles |
| Baghele et al., 2013, India [26] | 100 (25/75) | mean 17.8 | - | swimming | NR | presence according to Eccles and Jenkins |
| Bryant et al., 2011, New Zealand [27] | 31 (16/15) | 18–36; mean 24.2 | - | triathlon (swimming, cycling, running) | sports drinks | presence according to Eccles and Jenkins |
| Buczkowska-Radlińska et al., 2013, Poland [28] | 62 competitive swimmers (25/37), 69 recreational swimmers (34/35) | 14–16 | - | swimming | acidic drinks | Lussi Index |
| de la Parte et al., 2021, Spain [29] | 74 individual sports (21/53), 112 team sports (15/97) | 18–35; mean 24.7 | - | individual (fencing, tennis, table tennis, athletics, rowing, canoeing, cycling, cross-country skiing, alpine skiing, judo, triathlon, karate, trail running, paddle badminton, orienteering, bicycle motocross, swimming, rhythmic gymnastics, climbing, and taekwondo) or team (volleyball, basketball, ice hockey, handball, soccer, and water polo) | energy/sugary drinks | presence according to the WHO criteria |
### Table 2. Cont.

| Author, Year, Setting | Participants (F/M) | Age [Years] | Controls (F/M; Age) | Kind of Physical Activity | Kind of Beverages | Clinical Indices for Erosion |
|-----------------------|--------------------|-------------|---------------------|---------------------------|------------------|-------------------------------|
| Frese et al., 2015, Germany [30] | 35 (11/24) | 21–48; mean 36.8 | 35 (sex-and age-matched) | triathlon (swimming, cycling, running) | sports drinks | BEWE |
| Gallagher et al., 2018, UK [31] | 344 (114/230) | 18–39; mean 25.0 | - | athletics, gymnastics, sprint cycling and sprint swimming, swimming, cycling, rowing; football, rugby, hockey, sailing | NR | BEWE |
| Marro et al., 2019, Belgium [32] | 232 (97 with DS.) | 9–62; mean 23.9 | - | Special Olympics | NR | BEWE |
| Mathew et al., 2002, USA [33] | 304 (119/185) | 18–26; mean 19.0 | - | football, lacrosse | sports drinks | Lussi Index |
| Mulic et al., 2012, Norway [34] | 104 (68/36) | 18–32; mean 25.0 | 116 (75/41; 18-year-old) | fitness | acidic drinks (including sports drinks) | VEDE |
| Needleman et al., 2013, UK [35] | 278 (119/159) | 16–47; mean 25.7 | - | the London 2012 Olympic Games: track and field, boxing, hockey, swimming, water polo, judo, volleyball, shooting, football, weightlifting, fencing, archery, handball, beach volleyball, taekwondo, wrestling, cycling, basketball, canoeing, gymnastics, equestrian, sailing, table tennis, rowing, badminton | sports drinks | BEWE |
| Needleman et al., 2016, UK [36] | 187 (0/187) | 18–39; median 24.0 | - | football | sports drinks | BEWE |
| Nijakowski et al., 2020, Poland [37] | 102 (48/54) | 15–18 | 53 (35/18; 15–18) | team sports, fighting sports, water sports, individual sports | sports drinks | BEWE |
| Rao et al., 2019, India [38] | 56 (21/35) | mean 15.0 | - | swimming | fizzy drinks | presence according to the WHO criteria |
| Silva et al., 2021, Portugal [39] | 110 (54/56); 55 swimmers and 55 non-swimmers | 13–62; mean 27.9 | - | swimming, bodybuilding, football, boxing, volleyball, and running | energy/sports drinks | BEWE |
| Zebrauskas et al., 2014, Lithuania [40] | 132 (48/84) | 12–25 | - | swimming | sports and soft drinks | Lussi Index |

Legend: UK, the United Kingdom; USA, the United States of America; F, female; M, male; -, not applicable; NR, not reported; WHO, World Health Organisation; BEWE, Basic Erosive Wear Examination according to Bartlett et al.; VEDE, Visual Erosion Dental Examination.

### Table 3. Detailed characteristics of included studies considering potential impact of physical activity and sports drink consumption on dental erosion.

| Study | Physical Activity Frequency | Sports Drink Consumption Frequency | Erosion Frequency | Erosion Severity |
|-------|-----------------------------|-----------------------------------|------------------|-----------------|
| Antunes et al., 2017 [25] | 33.3% more than 3 times a week | 38.9% regularly | 19.4% | Classes 1 and 2 according to Eccles |
| Baghele et al., 2013 [26] | 95% more than 2 h a day | - | - | 90% | NR |
| Bryant et al., 2011 [27] | average training time per week 20.6 h | 84% | 53.8% more than 2 times a week | 0% | - |
| Buczkowska-Radlińska et al., 2013 [28] | competitive over 19 h per week; recreational less than 2 h per week | - | - | more than 26% in competitive and 10% in recreational | 100% with grade 1 according to the Lussi Index |
Table 3. Cont.

| Study                          | Physical Activity Frequency | Sports Drink Consumption | Sports Drink Consumption Frequency | Erosion Frequency                  | Erosion Severity                                      |
|--------------------------------|-----------------------------|--------------------------|-----------------------------------|-----------------------------------|--------------------------------------------------------|
| de la Parte et al., 2021 [29]  | at least 5 h per week       | NR                       | NR                                | 68.9% in individual sports, 55.4% in team sports | NR                                                     |
| Frese et al., 2015 [30]       | average 9.5 h per week      | 45.7%                    | average 592.9 mL per hour         | NR                                | average cumulative BEWE 9.6                             |
| Gallagher et al., 2018 [31]   | NR                          | -                        | -                                 | 41.4%                             | 28.9% with total BEWE > 8                              |
| Marro et al., 2019 [32]       | NR                          | -                        | -                                 | 62.1%                             | 27.1% with BEWE = 2, 26.4% with BEWE = 3               |
| Mathew et al., 2002 [33]      | NR                          | 91.8%                    | 64.3% at least 1 L daily          | 36.5%                             | 75.2% with grade 1 according to the Lussi Index         |
| Mulic et al., 2012 [34]       | 55% more than 3 times a week| NR                       | 3% once per day or more           | 64% (vs. 20% in controls)         | 37.3% with erosion involved dentine                     |
| Needleman et al., 2013 [35]   | NR                          | NR                       | -                                 | 44.6%                             | 38% anterior teeth and 48% posterior teeth with BEWE > 1|
| Needleman et al., 2016 [36]   | NR                          | 92.9%                    | 68.6% at least 3 times a week     | 53.1%                             | 21% with BEWE > 1                                      |
| Nijakowski et al., 2020 [37]  | NR                          | 17.6%                    | NR                                | 59.8% (vs. 22.6%)                 | 100% with total BEWE < 9                               |
| Rao et al., 2019 [38]         | average training time per session 2 h | -                      | -                                 | 48.2                              | NR                                                     |
| Silva et al., 2021 [39]       | average 4.2 times a week; 79.1% with training >60 min | 35.5%                    | 43.6% at least during each training | 83.6%                             | 8.7% with total BEWE > 8                               |
| Zebrauskas et al., 2014 [40]  | 21.2% more than 6 h a day   | 27.2%                    | daily                             | 35.6%                             | 100% with grade 1 according to the Lussi Index          |

Legend: -, not applicable; NR, not reported; BEWE, Basic Erosive Wear Examination according to Bartlett et al.

Most studies were included in the meta-analysis, the results of which are presented in the forest plots (Figures 3–5).

Figure 3. Forest plot presenting the summarised prevalence of dental erosion among physically active individuals.
Based on the included studies reporting the prevalence of erosion in physically active individuals, it was determined that the aggregate prevalence was approximately 46.55% [95% CI: 36.10–57.15%]. Similarly, in this group, the summarised frequency of the consumption of sports drinks was estimated to be around 56.02% [95% CI: 29.70–80.64%].

Altogether, regular consumption of isotonic drinks by athletes was associated with a more than 2.5-fold increase in the odds of erosive lesions. It should be noted that the total...
result was significantly influenced by a study of a group of swimmers whose consumption of sports drinks was associated with a more than 15-fold increase in the odds of dental erosion compared to non-swimmers who did not drink these beverages.

4. Discussion

Our systematic review found a relationship between the development of dental erosion and regular physical activity, especially with the accompanying consumption of sports drinks. Due to the variety of practised disciplines, it is difficult to relate summarised results to individual studies. Therefore, papers on relatively consistent groups of athletes were discussed in turn, starting with professionals and ending with amateurs.

A large proportion of the included studies investigated the effect of swimming on oral health, particularly the presence of erosive lesions. Buczewska-Radlińska et al. [28] analysed the prevalence of dental erosion among competitive and recreational 14- to 16-year-old swimmers in Szczecin, Poland. The competitive swimmers were from local sports clubs—junior subgroup training for about 7 years and senior subgroups training for about 10 years. Both subgroups spent over 19 h in the swimming pool per week. The recreational swimmers were randomly selected from students at high schools who were swimming once or twice per week and no more than 2 h per week. All participants trained in closely monitored, gas-chlorinated swimming pool water. Erosive lesions were observed significantly more often in the competitive swimmers than the recreational swimmers (26% and 10%, respectively). All lesions were grade 1, according to the Lussi classification. In the competitive swimmers, the anterior teeth were affected on both labial and palatal surfaces, whereas in recreational swimmers only palatal surfaces were affected. The erosion on the labial surfaces occurred only in senior competitive swimmers, especially in men. The authors suggest that the development of tooth erosion may be influenced by the length of training sessions and the duration of competitive swimming.

Similarly, Rao et al. [38] investigated the prevalence of oral health symptoms (such as dentinal hypersensitivity, dental erosion, and dental caries) among competitive swimmers from two training centres in Kottayam, India, and found that 69.6% of the included swimmers manifested dentinal hypersensitivity, 48.2% dental erosion and 39.3% dental caries. Among the athletes complaining of dentin hypersensitivity, 61% had accompanying erosive defects. Dental erosion was observed more frequently on the palatal surface of the maxillary anterior teeth followed by the mandibular anterior teeth. In the study group, the incidence of erosion increased with the years of regular training at the pool. The odds of developing dental erosion in swimmers training for more than 3 years was 5.3 times higher compared to the rest. Furthermore, swimmers training for more than 2 h during a training session were more likely to be marked with erosive losses. Although almost two-thirds of them consumed acidic beverages, no correlation was found between the frequency of drinking and the presence of tooth erosion. The authors confirmed that dental erosion is an occupational risk for professional swimmers.

Also, Zebrauskas et al. [40] determined the prevalence of dental erosion among competitive swimmers. The participants of the cross-sectional study were 12- to 25-year-old swimmers regularly practising in Kaunas, the second largest city in Lithuania. Among them, 57.6% of the athletes were under the age of 18. Erosive lesions were observed in 25% of the underage swimmers and 50% of the adult swimmers. In total, more than one-third of the study group presented the occurrence of at least one erosion defect. The lesions were located mainly on the labial surfaces of the anterior teeth, not including any molar teeth. All of them were evaluated as grade 1 according to the Lussi index. Participants who had practised swimming regularly for more than 10 years were 3 times more likely to develop dental erosion compared to younger and less experienced swimmers. Among the athletes with tooth erosion, only 23% reported experiencing dental hypersensitivity. Almost one-third indicated daily consumption of sports drinks, although no significant association was found with the occurrence of erosion lesions. However, in the study by Baghele et al. [26], among young competitive swimmers in India, dental erosion was observed in 90%. As the
length of daily training and years of competitive swimming increased, the frequency of erosive lesions also increased. The authors indicated that the high prevalence of dental erosion among swimmers should prompt appropriate preventive measures in this group.

Another group of studies focused mainly on the potential impact of sports drink consumption accompanying the training of professional athletes. Silva et al. [39] analysed if the consumption of acidic beverages, including energy drinks, could be associated with dental erosion in Portuguese athletes. In the cross-sectional study, the included participants were divided into four groups: swimmers who consumed or did not consume energy drinks, and non-swimmers (bodybuilders, football players, boxers, volleyball players, and runners) who consumed or did not consume energy drinks. Of the participants, 70% had been regularly involved in the sport for more than 2 years. Among them, 39 subjects consumed energy drinks, one-third of them during each training session. As many as 83.6% of the athletes in the study group had at least one erosion lesion. The teeth in the second and fifth sextants were the most frequently affected by erosive defects (69.1% and 59.1%, respectively). According to the BEWE index scoring, 43.6% of athletes demonstrated no risk of erosion, 49.1% low risk, 6.4% medium risk and 0.9% high risk. The authors evaluated the risk factors to be “at least low risk” of dental erosion, while considering the non-swimmers who did not use energy drinks as the control group. In the multivariate logistic analysis, the most statistically significant factor was the consumption of energy drinks in swimmers—the odds of erosion were more than 15 times higher than in the control group and more than 2 times higher than in the non-swimmers consuming energy drinks group. The findings suggested a complex influence of swimming as a sport and the habit of consuming energisers on the development of erosive defects, requiring regular dental check-ups.

Frese et al. [30] investigated the impact of endurance training on oral health, regarding tooth erosion and dental caries. The study sample included 35 triathletes and 35 non-exercising controls. Per week, the athletes spent the most time on cycling (4.5 h), then running (3.2 h), and swimming (1.8 h). During training, 51.4% consumed water, 45.7% sports drinks and 2.9% no drinks. Additionally, the consumption of sports nutrition was declared by 74% of the athletes but was without a significant influence on the determined oral health parameters. The triathletes presented a medium risk level for dental erosion, whereas the non-athletes presented a low-risk level (mean cumulative BEWE scores of 9.6 and 7.3, respectively). Multivariate logistic regression showed no association between erosion risk in athletes and the type of beverage consumed during training, the amount of drinking during exercise, or the years of physical activity. On the other hand, the athletes did not differ from the non-athletes in dental caries prevalence. Additionally, as the cumulative exercise time per week increased, the DMFT values also increased. Surprisingly, in the study by Bryant et al. [27], among the 10 competitive elite triathletes who received oral examination, none had clinical evidence of erosion, while active caries was observed in 4 individuals. The study group consisted of 35 adult triathletes who trained for at least 10 h a week. The most training time per week was spent on cycling (about 9 h), followed by swimming (about 6 h), and running (about 5 h). During exercise sessions, all athletes consumed water and 84% also consumed sports drinks.

Moreover, Mathew et al. [33] evaluated whether regular consumption of sports drinks was associated with dental erosion among athletes from the Ohio State University. A total of 91.8% of the participants regularly consumed sports drinks, and most of them drank at least a litre a day. The prevalence of tooth erosion was found to be 36.5%, of which 75.2% represented enamel erosion. The occlusal surfaces of the mandibular first permanent molar were the most often affected by erosive lesions. Additional hypersensitivity was reported by 12.9% of the athletes. Among the consumers of sports drinks, 36% demonstrated dental erosion. The authors showed no significant correlation between the consumption of sports beverages and the severity of erosion lesions. Additionally, multiple regression analyses confirmed no association between the occurrence of dental erosion and the use of sports
drinks, including the quantity and frequency of consumption, brand name, years of usage, and home use of sports drinks.

Our recent study [37] aimed to determine the risk factors for erosive lesions in young sports professionals. The sample involved 155 students from Athletic Championship High School in Poznan, Poland. The participants were drawn to the study group from classes with a sports profile, and to the control group from the others, who did not declare regular physical activity. Based on the BEWE index, the presence of erosion lesions was found in 59.8% of the athletes and only in 22.6% of the controls. According to multivariate logistic regression, practising in water sports (including swimming) increased the odds of erosion occurrence by 14 times. Moreover, consumption of mainly water instead of isotonic drinks during exercise reduced the odds of erosive lesions by 70%, and sports nutrition increased the odds by almost four times. The indicated relationships were confirmed by multivariate correspondence analysis. We proposed a model to predict the risk of dental erosion in physically active adolescents based on the type of practised sport and their drinking habits during training sessions.

Some studies also identified and compared the incidence of tooth erosion in team sports. Needleman et al. [36] evaluated oral health in a representative group of professional football players in the UK. The cross-sectional study was performed in eight football clubs: five Premier League, two Championship, and one League One. One hundred eighty-seven footballers were recruited and represented above 90% of each senior team. Although almost three-quarters of them declared a previous dental check-up within the past 12 months, the oral health status was poor. A total of 36.9% of the players demonstrated active dental caries, 53.1% dental erosion, and 5% at least moderate periodontal disease. The most advanced erosion defects (grades 2–3 according to BEWE) were observed on the anterior teeth in about 20% of the cases, and a similar amount were on posterior teeth. Only 7.1% of the football players reported drinking sports beverages less than once a week. In contrast, 23.1% consumed isotonic drinks more than six times a week. The authors found no correlation between the sports drink consumption frequency and the occurrence or severity of dental erosion.

Furthermore, Gallagher et al. [31] assessed the oral health status (e.g., erosive tooth wear, dental caries) in a representative sample of UK elite athletes from different sports. They recruited 352 athletes representing 11 sports disciplines, including 50 in the strength and power category, 143 in the endurance category, and 159 in the mixed category (in total, eight questionnaires were not returned). Dental caries (defined as ICDAS code ≥3) was observed in 49.1% of the athletes and erosive tooth wear (defined as BEWE score ≥7) in 41.4%. For both mentioned diseases of the hard tissues of teeth, the odds of their development were about twice as high for team sports than endurance sports. Erosive lesions were found most frequently in football players (73.1%), and least frequently in sailors and rowers (each 26.7%). Similarly, de la Parte et al. [29] determined the oral health status of elite athletes according to the performed sports type. The participants consisted of 186 elite athletes divided into individual and team sports (74 and 112, respectively). The athletes practising individual sports had higher DMFT values (especially decayed and missing teeth), corresponding with the worse dental hygiene level, compared to the team sports athletes. Additionally, they presented a tendency for more frequent erosion loss (68.9% vs. 55.4%, p-value 0.089). Both groups of athletes did not differ in the frequency and amount of consumption of energisers and sweetened beverages. However, the athletes in team sports consumed such beverages much more frequently during recovery (58.8% vs. 47.3%).

Two studies dealt with diverse groups of athletes participating in the Olympic Games and disabled athletes participating in the Special Olympics. Needleman et al. [35] evaluated the oral health status in athletes participating in the London 2012 Games. The study participants represented 25 disciplines, with track and field, boxing, and hockey being the most common. Less than half of the athletes attended a dental check-up in the past 12 months. The assessed oral health status was unsatisfactory. A total of 55% of the athletes demonstrated active dental caries, 45% tooth erosion, and 15% periodontal disease. The
majority of erosive lesions were grade 2 or 3 according to BEWE, and more frequently found on posterior teeth. No correlation was found between the consumption of sports drinks and the incidence of dental erosion. However, the effect of isotonic drinking frequency on the presence of erosion defects in anterior teeth was observed.

In contrast, Marro et al. [32] determined the presence and severity of erosive tooth wear in athletes with intellectual disabilities who participated in the Special Olympics Belgium 2016. The sample was organised into three groups: athletes with Down syndrome under the age of 25, older athletes with Down syndrome, as well as athletes with other intellectual disabilities. Over half of the young athletes with intellectual disabilities demonstrated at least one tooth surface affected by erosion. Among them, 10.5% showed the BEWE score equalling 3. Moreover, the young athletes with Down syndrome presented a significantly higher prevalence of dental erosion (69.2%) and a percentage of athletes with the high-risk level of erosive tooth wear (BEWE sum above 13 for 7.69%). Both the frequency and severity of erosive defects in the athletes with Down syndrome increased with age. The authors suggested that the possible reason for exacerbation of the severity of erosive lesions in DS athletes might be the combination between gastroesophageal reflux disease and bruxism. Additionally, they stressed the limitation of their study—the exclusively selected group of athletes with intellectual disabilities received regular medical and dental care, as well as being well-supported by their families.

A few included studies concerned amateur physically active individuals. Antunes et al. [25] assessed the prevalence and potential risk factors for dental erosion in amateur athletes at running events. In the study, 108 amateur runners from Rio de Janeiro, Brazil, participated. A total of 38.9% of the athletes regularly consumed sports drinks. Erosive lesions were found in only 19.4% of the runners. Surprisingly, the posterior teeth were more often affected than the anterior teeth, both in the maxilla (28.6% vs. 4.8%) and in the mandible (61.9% vs. 23.8%). The incidence of dental erosion was significantly associated with running frequency per week and time spent during competition. In contrast, the consumption of isotonic drinks was not shown to be related to the occurrence of erosion cavities.

On the other hand, Mulic et al. [34] described the prevalence and severity of dental erosive wear among physically active young adults. Dental erosive wear was noticed in 64% of the participants exercising at a fitness centre twice or more per week. Each training session, lasting between 60 and 90 min, required stationary bike ergometers and treadmills. Only 3% of the respondents reported a high consumption of sports drinks. In the group over 25 years of age, erosive defects were observed more frequently than in the younger group (76% vs. 57%, respectively). In contrast, in the control group of 18-year-olds, the incidence of erosion was 20%. Most of the erosive lesions affected the enamel and were localised on the upper incisors (33%). If lesions advanced to dentine were present, they were found in the first molars (12%), and significantly more often in the men, especially with reduced salivary flow rate after exercise. The participants with erosive defects were more likely to have reduced salivary secretion during training. Therefore, the authors postulated that decreased salivary flow rate during exercise may be significantly associated with the formation of erosive lesions.

5. Conclusions

Regular physical activity is associated with an increased risk of erosive lesions, especially under the influence of the frequent consumption of sports drinks. Based on our review, approximately half of the studied athletes manifested dental erosion. However, it is difficult to establish transparent quantitative relationships due to the heterogeneity of the included studies (different age groups, various sports disciplines).
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