

Systematic Review

Dental Erosion and Diet in Young Children and Adolescents: A Systematic Review

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Abstract: Dental erosion is the irreversible loss of tooth enamel caused by acid attack without any bacterial involvement. Interest in dental erosion has increased considerably during the past decade. This paper aims to determine the prevalence of and association of dental erosion with diet or beverages in children. A systematic review of the literature has been carried out in accordance with the PRISMA recommendations. A search was performed in PubMed, Embase Scopus and Web of Science databases, and completed manually. Those studies that dealt with erosive risk factors related to diet and that included their effect on deciduous or mixed dentition were selected. Dual independent screening, data extraction and risk of bias assessment were concluded. A total number of 708 articles were identified from the initial electronic search of the four databases. Some 466 articles were selected after duplicated articles were discarded. After reading the title and abstract, we eliminated 376 articles; the remaining 90 were meant to be read in order that we could dispatch the ones that did not answer the research question or the inclusion criteria. A total of 25 articles remained for the systematic review. Erosive lesions are favored by the consumption of carbonated and isotonic drinks, fruit juices and acid sauces. Carbonated, isotonic drinks and fruit drinks favor the development of erosive lesions, not so the consumption of fruit juices mixed with dairy products such as milkshakes, yogurts and/or tea. The findings of this article will help researchers, academics and students to characterize the scientific results regarding dental erosion and diet, to evaluate management strategies and to identify significant topics and questions that will help to design future research with the aim of the prevention of the disease. Registration number: CDR42023389750.

Keywords: beverage; dental erosion; diet; pediatric dentistry; young adult

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1. Introduction

Dental erosion is defined as a chemical process characterized by acid dissolution of dental hard tissue not involving bacteria. For decades, dental erosion has not been a condition extensively studied either in private or clinical practice, or in the scientific field [1–6].

Nevertheless, due to a significant increase in its prevalence in recent years, a shift has occurred, triggering an interest in studies about dental erosion and its research in different health disciplines, especially among children and adolescents [7].

Dental erosion is a multifactorial disease where the presence of acids of non-bacterial origin interacts with the tooth surface, producing over time a manifestation of the disease, through lesions of different degrees of evolution [8].

These acids that generate the dissolution of the mineralized tooth structure by direct contact with it reach the oral cavity from different sources:

- (1) Intrinsic sources. The hydrochloric acid coming from the stomach of the patient itself generates the dissolution of the enamel due to its low pH, around 1. This occurs in people who suffer from gastroesophageal reflux, regurgitation, persistent vomiting and especially in patients suffering from eating disorders such as anorexia and bulimia [9,10].
- (2) Extrinsic sources. These consist in exogenous acids from the consumption of acidic either solid or liquid foods such as fruits, fruit juices and carbonated beverages. They can also come from acidic medications such as ascorbic acid (vitamin C) or acetylsalicylic acid (aspirin®) [11,12].
- (3) Idiopathic sources. These come from acids of unknown origin, where neither the anamnesis nor the examination nor the complementary tests allow us to clarify the etiology of the observed lesion. The percentage of these cases is very small [8,11].

There is a strong correlation confirmed by several published studies between the consumption of solid foods and acidic liquids and dental erosion as a consequence of its chemical characteristics such as its low pH, its low buffering capacity and its low mineral content in calcium, phosphate and fluoride [9,13].

The regular intake of acidic foods such as fresh fruits and vegetables, pickled foods or vinaigrettes and sauces such as ketchup present a high erosive potential, determined above all by their pH below 4.55 [14].

During the past decades, in certain Western societies, especially in America and Europe, there has been a significant increase in the consumption of non-alcoholic beverages, mainly juices and soft drinks [15–20].

This increase in the intake of juices and low pH carbonated beverages has been correlated with a significant increase in the prevalence of dental erosion. This prevalence varies in children from 56% to 85% of those who consume soft drinks daily; of whom 20% consume them four or more times per day [21].

The frequency of intake of these drinks also influences the development of dental erosion. This statement is based on studies such as that of Nahás et al. (2011), who noted that patients who drank soft drinks during the whole week had more erosion than those who only consumed them during weekends, concluding that the higher the frequency of consumption, the greater the risk of suffering from the disease [22].

In addition to the frequency factor, there are authors who consider the amount of ingested product as an important factor [22]. Al-Dlaigan found in 14-year-old British children a high correlation between the amount of cola ingested and other soft drinks, apple juice and sports drinks, and the presence of dental erosion [22].

The heterogeneity in the diagnosis and the variants that can produce erosion depending on the region in which they are studied make this review relevant in order to provide the pediatric dentist with a broad vision of which are the products that present a high erosive potential. Therefore, the objective of this study is to determine the prevalence and association of dental erosion and diet or beverages in children and teenagers.

2. Materials and Methods

The protocol for this systematic review was written and registered on PROSPERO (registration number: CDR42023389750). The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews (PRISMA) guidelines.

The inclusion criteria are listed here following the PECO(S) statement:

- Population (P): individuals with primary dentition or mixed dentition.
- Exposure (E) and Comparison (C) factors: dietary habits (such as frequency of consumption of fruit juice, soft drinks, and fruits).
- Outcome (O): prevalence of erosive tooth wear, measured by different erosion indices.
- Studies (S): observational studies, such as cohort, case control, and cross-sectional.

The exclusion criteria included the following:

- Studies on the cause of the erosion that is not due to diet.
- Studies on the pediatric age that has been exceeded.
- Studies on diagnosis and management of erosive tooth wear only.
- In vitro studies, laboratory studies, conference papers, and reviews.

A systematic electronic search was carried out from November 2022 to December 2022 in four electronic databases (Pubmed [23], Embase [24], Web of Science [25], and Scopus [26]). Some of the authors had to be contacted by email in order to request additional information. MeSH terms and the subject index used for the search were as follows: pediatric dentistry, young adults, diet, water, milk, juice, carbonated, soft drinks, dental erosion and tooth erosion.

The designed search strategy considered previous studies in the field and their most cited descriptors. The keywords were: (“pediatric AND dentistry” OR “young adult”) AND (diet OR water OR milk OR juice OR carbonated OR “soft drink”) AND “dental erosion”. A duplicates search was performed by identifying references of the search strategy and exporting them from each database to Mendeley’s reference management software (Elsevier, Amsterdam, The Netherlands). After that, two reviewers (MD-CR and L-MM) independently assessed the titles and abstracts of all identified articles. In the case of discrepancy, a third author (E-GM) had to be consulted. Several articles needed to be read in the cases where the abstract did not provide enough information in order to conclude. Finally, those articles which met the requirements were included in the study.

Different variables for the study characteristics, methodology and results were established. Author, location and year were used in order to identify the features of the different studies. The erosion index was registered as well as the evaluation factors. The significant results and the conclusions obtained from each study analyzed were included in the outcome variables.

The quality of the studies was assessed by the same reviewers independently, using the NIH quality assessment tool for observational cohort and cross-sectional studies. In case of any discrepancies in quality assessment, consensus was reached between the reviewers and if this was not possible a third reviewer was consulted.

3. Results

3.1. Study Selection

From the initial electronic search of the four databases, 708 articles were identified: 304 from PubMed, 101 from Embase, 164 from Scopus and 139 from Web of Science. After we had eliminated the duplicate articles, a total of 466 remained. After we had read the title and abstract, 376 articles were eliminated, leaving 90. Thanks to a reading of the full text, 65 were eliminated for not answering the research question or the inclusion criteria, leaving a total of 25 articles for the systematic review. The PRISMA flowchart (Figure 1) provides an overview of the item selection process [27].

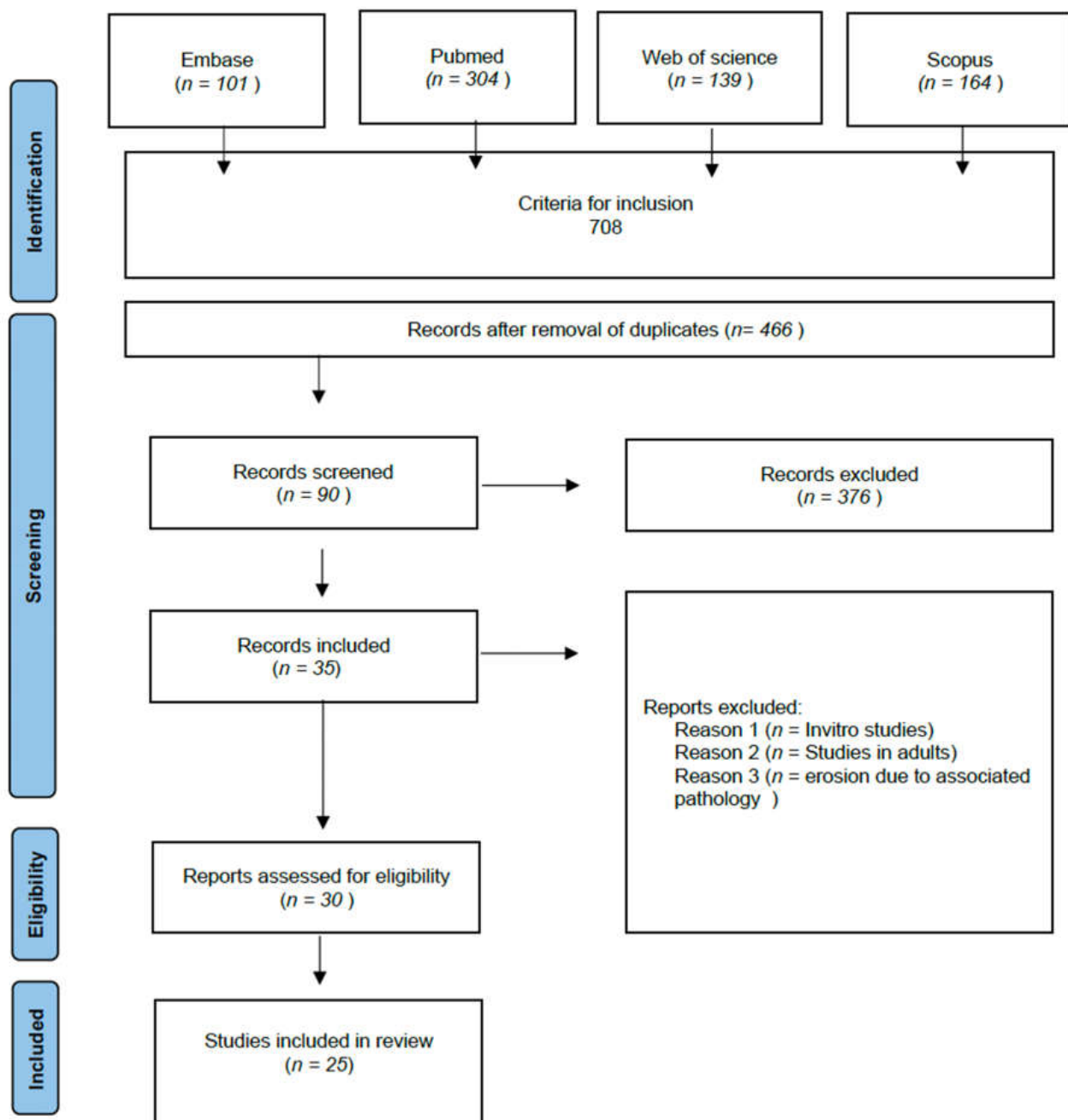


Figure 1. PRISMA flowchart of study selection process.

3.2. Study Characteristics

Tables 1 and 2 show the selected articles.

Table 1. Summary of articles.

Author Year	Type of Study	Number of Patients	Gender	Age Range (Years)	Recruitment	Factors Evaluated	Erosion Index	Results
Ludovichetti, F S. 2022 [28]	Clinical investigation	231	*	Pediatric age	Italy	Diet OH	BEWE	Low RE > High RE
Dantham, P. 2021 [29]	Cross-sectional	500	*	6–10	Nellore district, Andhra Pradesh. India.	Diet OH Social class	BEWE	Low RE
Hasheminejad, N. 2020. [30]	Cross-sectional	600	300 male 300 female	12–15	Kerman, Iran.	Diet Gender Age	DMFT TWI	Low RE
Melbye, E L. 2020 [31]	Cross-sectional	850	731 male 119 female	13–19	Rogaland county, Norway.	Diet knowledge	Questionnaire	Low RE
Duangthip D. 2019 [32]	Cross-sectional	1204	553 male 651 female	3–5	Hong Kong	Gender Age Parental education level Diet OH Caries	BEWE	Low RE > Medium RE > High RE
Gopinath VK. 2019 [33]	Cross-sectional	403	48 male 355 female	5	Sharjah, United Arab Emirates	Gender Diet Caries Nationality	TWI	Medium RE
González-Aragón Pineda, Á E. 2019 [34]	Cross-sectional	512	*	11–14	Mexico City	Diet	ETW BEWE	Dairy products Low RE
Skalsky Jarkander, M. 2018 [35]	Cross-sectional cohort	1335	547 male 524 female	15–17	Stockholm County	Diet Behavioral factors	SEPRS	Low RE > Medium RE > High RE

Table 1. Cont.

Author Year	Type of Study	Number of Patients	Gender	Age Range (Years)	Recruitment	Factors Evaluated	Erosion Index	Results
Al-Dlaigan. 2017 [36]	Cross-Sectional	388	182 male 206 female	3–5	Kindergartens. Saudi Arabia	Diet	TWI	Low RE > Medium RE > High RE
Cheng, J. 2016 [37]	Cross-Sectional. Pilot study	84	*	8–10	Soroti, Uganda	Diet	DMFT	Low RE
Hasselkvist, A. 2016 [38]	Prospective longitudinal study	227	*	13–14	Örebro, Sweden	Diet lifestyle	Questionnaire	Low RE > Medium RE > High RE
Franklin, S. 2015 [39]	Controlled, blinded, non-randomized clinical trial	100	*	10–14	Punjab, India	Fruit juice	DMFT	Smaller drop in salivary and plaque pH ($p < 0.5$) Significant reduction in perceived taste ($p < 0.001$)
Huang L. 2015 [40]	Cohort	154	69 male 85 female	2–4	University of Queensland	Social Medical history Diet	TWI	Low RE
Aguiar, Yéska Paola Costa. 2014 [41]	Population-based study.	675	*	5–19	Campina Grande, PB, Brazil.	Diet Gender Social status	Questionnaire	Low RE
Habib M. 2013 [42]	Cross-Sectional	243	*	2–12	Kansas City Metropolitan	Diet Gender	TWI	Low RE for 2–4 years old Low RE for 12 years old
Nayak S. 2012 [43]	Cross-sectional	1002	*	5	Belgaum, Karnataka, India	Diet OH	SES Diet	Oral hygiene practices no DE
Okunseri, C. 2011 [44]	Experimental studies	523	*	13–19	United States	Diet Gender Race	ETW	Medium RE males Low RE Blacks
Huew, R. 2011 [45]	Cross-sectional observational	791	*	12	Benghazi, Libya	Diet	UK National Diet and Nutrition Survey	Medium RE

Table 1. Cont.

Author Year	Type of Study	Number of Patients	Gender	Age Range (Years)	Recruitment	Factors Evaluated	Erosion Index	Results
Gurgel, C. 2011 [46]	Random single center cluster	414	*	12–16	Bauru/Brazil	Diet Lifestyle	O'Brien	Medium RE
Murakami, C. 2011 [47]	Cross-sectional	967	47 male 920 female	3–4	Children attending a statutory National Children's Vaccination day	Age Caries SES Diet Acid reflux	ETW TWI	Medium RE
Hasselkvist, A. 2010 [48]	Cross-sectional	609	*	5–19	Swedish	Diet	SEPRS	High RE 18–19 year-old
Correr, G M. 2009 [49]	Cross-sectional study	389	*	12	Piracicaba, São Paulo, Brazil	Gender dietary habit, salivary	O'Sullivan	Medium DE
Al-Majed, I. 2002 [50]	Cross-sectional	354	100 male 254 female	5–6	Elementary Schools Arabia Saudi	Diet OH	TWI	Low RE
Al-Malik M. 2001 [51]	Cross-sectional	987	*	2–5	London, UK	Diet OH Social Class	TWI	Medium RE
Millward, A. 1994 [52]	Cross-sectional study	101	52 male 49 female	9	University of Birmingham	Diet	Tooth wear index of smith and knight	Medium RE > High RE

BEWE: Basic Erosive Wear Examination; DMFT: Decayed, Missed and Filled Teeth DMFT; TWI: Tooth Wear Index; ETW: Erosive Tooth Wear; SEPRS: Simplified Erosion Partial System; OH: Oral Hygiene; DE: Dental Erosion; RE: Risk Erosion. O'Brien: Children's Dental Health in the United Kingdom. * Data not specified in the article.

Table 2. The National Institutes of Health (NIH) quality assessment tool for observational cohort and cross-sectional studies. Website: <https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools> (accessed on 27 November 2022) [53].

Author year	Research Question	Study Participants	Participation Rate	Populations	Sample Justification	Timeframe	Different Levels	Exposure Measures	Exposure(s) Assessed	Outcome Measures	Assessors Blinded	Loss to Follow-Up	Potential Confounding Variables	Quality Rating
Ludovichetti, F S. 2022 [28]	○	○	○	○	○	○	○	○	○	○	○	○	○	
Dantham, P. 2021 [29]	●	●	●	●	●	●	●	●	●	●	●	●	●	G
Hasheminejad, N. 2020. [30]	●	●	●	●	●	●	●	●	●	●	●	●	●	G
Melbye, E L. 2020 [31]	●	●	●	●	●	●	●	●	●	●	●	●	●	G
Duangthip D. 2019 [32]	●	●	●	●	●	●	●	●	●	●	●	●	●	G
Gopinath VK. 2019 [33]	●	●	●	●	●	●	●	●	●	●	●	●	●	G
González-Aragón Pineda, Á E. 2019 [34]	●	●	●	●	●	●	●	●	●	●	●	●	●	G
Skalsky Jarkander, M. 2018 [35]	●	●	●	●	●	●	●	●	●	●	●	●	●	G
Al-Dlaigan. 2017 [36]	●	●	●	●	●	●	●	●	●	●	●	●	●	G
Cheng, J. 2016 [37]	●	●	●	●	●	●	●	●	●	●	●	●	●	G
Hasselkvist, A. 2016 [38]	●	●	●	●	●	●	●	●	●	●	●	●	●	G
Franklin, S. 2015 [39]	○	○	○	○	○	○	○	○	○	○	○	○	○	
Huang L. 2015 [40]	●	●	●	●	●	●	●	●			●	●	●	G

Table 2. Cont.

Author year	Research Question	Study Participants	Participation Rate	Populations	Sample Justification	Timeframe	Different Levels	Exposure Measures	Exposure(s) Assessed	Outcome Measures	Assessors Blinded	Loss to Follow-Up	Potential Confounding Variables	Quality Rating
Aguiar, Yéska Paola Costa. 2014 [41]														G
Habib M. 2013 [42]														G
Nayak S. 2012 [43]														G
Okunseri, C. 2011 [44]														
Huew, R. 2011 [45]														G
Gurgel, C. 2011 [46]														G
Murakami, C. 2011 [47]														G
Hasselkvist, A. 2010 [48]														G
Correr, G M. 2009 [49]														G
Al-Majed, I. 2002 [50]														G
Al-Malik M. 2001 [51]														G
Millward, A. 1994 [52]														G

 : Yes;  : No;  : No answer; G: Good quality.

The average number of participants in all studies was 600. The study carried out by Skalsky, M. [35] was the one that explored the highest number of patients with a total of 1335, while Cheng, J. [37] analyzed the lowest number of patients with a total of 84.

When we studied the age of the participants in the different studies, we found that the average age was five years. Studies such as those by Huang, L. [40], Habib, M. [42] and Al-Malik, M. [50] studied two-year-olds, while the studies by Melbye, E. L. [31], Cheng, J. [37], Aguiar, Y.P. [41], Okunseri, C. [44], Hasselkvist, A. [48] focused on 19-year-old patients.

When assessing the Erosion index used in different studies, the most used are Basic Erosive Wear Examination: BEWE [28,29,32], followed by the Tooth Wear Index: TWI [23,32,40,42]. Only three studies used qualitative questionnaires for assessing the erosion [31,41,48].

Lastly, regarding the study's methodology, 19 were cross-sectional, the rest being a clinical investigation [28], one prospective longitudinal study [48], a controlled, blinded, non-randomized clinical trial [39,46], a population-based study [41] and an experimental one [44].

4. Discussion

There is a consensus in the scientific community regarding the increase in the prevalence of dental erosion as a result of the frequent intake of acidic foods and beverages such as juices and soft drinks [15–17].

In recent investigations, a high prevalence of lesions that affect enamel and dentin can be observed with percentages that vary between 30 and 90%, while lesions that affect the pulp are scarce. Thus, the initiation and progression of enamel demineralization caused by the consumption of acidic beverages is a multifactorial process that depends on the pH and acid content of the beverage, as well as intraoral pH changes [39,54,55].

In most articles, closed questionnaires on dietary habits were used in order to collect data from patients [33,48]. This methodology allows us to assess the risk of dental erosion based on dietary and behavioral factors, preventing the patient from forgetting or not mentioning certain aspects because they are not considered dangerous when in fact they are likely to cause dental erosion [56].

Some studies reviewed [40,48] show that the correlation between the consumption of solid foods and acidic liquids and dental erosion was confirmed, making it necessary to focus on the prevention of the disease, especially on the modification of their consumption. Habib et al. [42] investigated the frequency of intake of different drinks, and noticed a positive association between the prevalence of dental erosion and the consumption of soft drinks, isotonic drinks and fruit juices, concluding that the participants with a high consumption of said drinks presented more serious dental erosion compared to those with a lower intake [57].

In contrast, Cheng, J. [37], Aguiar, Y.P. [41], Gurgel, C. [46], and Al-Malik, M. [51], concluded that there was no relationship between erosion and social class, or erosion and oral hygiene practices. In the same vein, Okunseri, C. [44], states that there is no association between race or ethnicity and dental erosion.

When analyzing dairy products and tea in the present work, authors such as Duangthip, D. [32], and Okunseri, C. [44], observed a low prevalence of dental erosion in patients who consume these beverages, which indicates the protective nature of dairy drinks (milk, shakes and yogurts) and tea against the development of erosive lesions.

Huew, R. [45], studied the frequency of consumption of acidic fresh fruits and observed a positive correlation between the consumption of apples, oranges, bananas and grapes and the development of erosive lesions. Nayak, S. [43], found that certain dietary factors such as canned juices, raw mango, gooseberry, tamarind, honey, buttermilk, and other beverages showed a significant correlation with dental erosion.

Most studies are carried out on adolescents because they are mature enough to perceive any change in taste between different drinks using a simple scoring method. They have a greater understanding of the questionnaires and offer greater collaboration than younger children. It should be highlighted that Huang, L. [40], affirms that at an older age, the erosive prevalence increases. Therefore, it must be diagnosed in order to provide the appro-

appropriate preventive measures. Thus, and as stated by Ludovichetti, F.S. [28], Dantham, P. [39], and Melbye, E.L. [31], educational programs for the community are necessary in order to implement early preventive measures [58].

Franklin S. et al. [39], advocate the use of fortified beverages (calcium-modified mixed fruit juices) that could be a good source of calcium for any population not able to consume milk and dairy products due to allergies or lactose intolerance. These fortified food products are called “functional foods” and are believed to address the traditional division between the pharmaceutical and food sectors. Further research is needed to critically assess the safety of such food products, especially with regard to oral health. Intraoral factors such as saliva composition, bacterial flora, and enamel fluoride composition in different study populations complicate even further this field of research. As stated in the study by Hasselkvist, A. [48], a common epidemiological registry system on an international level should be developed in order to reach consensus and unify diagnostic criteria considering that the lack of consensus in the results may be due to the differences found between the studies regarding the sample size, the dental erosion index used and/or the items used in the questionnaires to assess the frequency of intake of acidic foods, together with the fact that the study of a multifactorial pathology in which each factor is influenced by others until a balance is reached may be compatible with health or disease in a very individual way [59,60].

This study must be interpreted cautiously. The main limitations are the heterogeneity of the articles in terms of diagnostic methods and for the interpretation of results. In the same way, the results obtained in this review provide a general idea about erosive foods, but could be biased by the customs or eating habits of each country.

The present study presents a good solidity/quality because the Prisma recommendations have been followed. Although the level of evidence should be classified as moderate, since the estimator of the effect is likely to be close to the real effect, the need for new standardized studies is required to establish common diagnostic criteria and thus combine subsequent treatments and guidelines.

In the same way, a study on the evidence of the questionnaires used, or the realization of a diagnostic protocol for the evaluation of erosion in temporary dentition, would be necessary.

5. Conclusions

The consumption of carbonated, isotonic drinks and fruit drinks favors the development of erosive lesions, not so the consumption of fruit juices mixed with dairy products such as milkshakes, yogurts and/or tea. In most studies, a relationship between the consumption of fruits and acid sauces and the prevalence of dental erosion was observed.

The findings of this article will help researchers, academics and students to characterize the scientific results regarding dental erosion and diet, to evaluate management strategies and to identify significant topics and questions that will help to design future research with the aim of the prevention of the disease.

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