FLUORIDE
Quarterly Journal of The International Society for Fluoride Research Inc.

Online Fitness and Dietary Supplementation: Investigating the Impact of Fluoride Intake on Dental Health Among Athletes and the General Population

Unique digital address (Digital object identifier [DOI] equivalent):
https://www.fluorideresearch.online/epub/files/341.pdf

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Accepted: 2025 Apr 1
Published as e341: 2025 Apr 2

Abstract: The substance fluoride maintains dental health through two main functions which protect teeth from cavities and strengthen enamel. The effects of fluoride supplementation on athletes do not have sufficient research despite the overall population reaping benefits from fluoridated water and dietary sources.
Aim:The research reviews systematically how alterations in diet or water fluoridation affect dental caries prevention together with enamel remineralization among athletes compared to typical individuals.
Methods:The study utilized PubMed together with Scopus along with Web of Science databases to search for relevant studies published between 2014 and 2024. A set of studies qualified for selection based on their evaluation of fluoride effects on dental outcomes within both athlete groups and general public populations. Data were retrieved from both randomized controlled trials and cohort studies and observational studies. The studies received risk of bias evaluation using both Cochrane Risk of Bias tool and Newcastle-Ottawa Scale. The study conducted both qualitative analysis and quantitative meta-analysis.
Results: The review analysis included 71 eligible studies from the search. The evaluated data showed fluoride supplementation applied through both diet and water fluoridation achieved lower dental caries rates while improving enamel formation in athletes and everyone else. Athletes obtained slightly greater benefits because of their particular consumption behaviors regarding hydration and nutrition. Athletes who drank fluoridated sports drinks experienced a 25-30% reduction in dental caries risk than athletes using non-fluoridated drinks according to the research findings.
Conclusion: The scientific evidence shows fluoride supplementation helps prevent tooth decay together with enamel healing for athletic groups while having similar benefits for common community members. The increased fluid consumption and different dietary patterns among athletes lead them to achieve somewhat larger beneficial effects through fluoride supplementation. The consumption of excessive fluoride amounts through sports drinks poses a risk for dental fluorosis while also bringing possible side effects. Healthcare professionals should create tailored fluoride supplementation plans for athletic groups.
Keywords: fluoride supplementation, dental health, dental caries, enamel remineralization, athletes

INTRODUCTION

An important facet of overall health and quality of life, oral health is an element that needs to be addressed. Fluoride has been considered among the most effective of the interventions for maintaining and improving oral health: preventing dental caries and restoring enamel remineralization [1, 2]. Water fluoridation programs and dietary supplementation of fluoride are common strategies for delivering fluoride to the population so as to reduce tooth decay and to improve overall dental health. However, its use in the general population is well established in preventing dental cavities where water fluoridation takes place.

The scientific community now investigates how fluoride affects different population demographics such as public groups and athletes. Different dietary patterns and higher levels of physical activity cause athletes to face various oral health requirements than people in the common population. The areas of China which face severe fluoride contamination problems in air and water supply have become a national concern because of special challenges faced by local athletes. The residents of fluoride-exposed locations face increased fluoride ingestion through their consumption of fluids and food as well as through airborne chemicals that might impact their dental condition and breathing system. The parallel increase in physical exercise and athletic supplements combined with sports drink consumption creates unique oral healthcare needs that go beyond typical population requirements. Studies about fluoride exposure in athletes remain sparse while researchers should determine if high fluoride consumption alters athlete health outcomes versus those of the general population.

The problem of fluoride contamination in Sindh and Punjab regions of Pakistan makes water supplies dangerously unsafe for residents. Athletes residing in specific areas encounter elevated fluoride levels from drinking water and food as well as breathing air thus damaging their oral health and their respiratory system. Hashtag athletes who consume more calcium-rich food and drink are susceptible to increased fluoride consumption that may result in dental health problems dissimilar to those of normal citizens. Research on the particular fluoride effects on athletes operating in Chinese and Pakistani regions must continue because environmental fluoride presence remains a substantial public health concern. Typically, their nutrition includes specialized dietary supplements, higher water intake, and, in some situations, greater quantity of energy drink or sports beverage that may possibly influence how fluoride is being absorbed and retained in the body [3]. In addition, their physcial exertion is quite intense, involving loss of fluid through sweat, which theoretically may affect how fluoride is metabolized and used by the body.

Although fluoride is proven to be beneficial in dental health, no research has taken place to look into the effects of fluoride supplementation sport athletes. Unlike most studies, this one focuses on athletes who have unique health and nutritional needs which may affect the effect of fluoride on their dental health [3]. In addition, it is uncertain whether fluoride supplementation, through diet or fluoridated water, results in differential impact on oral health outcomes in athletes when compared to those not participating in athletics and particularly for caries and enemal demineralization prevention and overall oral hygiene.

Problem Statement

Fluoride intake is recognized as being involved in improving the dental health outcomes, especially the prevention of dental caries and enhancement of enamel remineralization. Nevertheless, fluoride supplementation in athletes remains its effect almost unexplored. Because of their unique physical and nutritional characteristics, athletes may take in, handle or react to fluoride differently than the general population. There is significant questions regarding the adequacy and efficacy of fluoride supplementation for this group and this gap in the literature. As athletes have higher fluid loss, train harder and demand a different diet from that of the general population, it is imperative to determine whether supplementation of fluoride to athletes through dietary sources and water, as is done in the general population, has the same or different effects in influencing the dental health of athletes.

Since there is a lack of comprehensive research, it is necessary to investigate if fluoride intake differs among athletes compared to the general population, and if so, how these differences relate to dental health. This body of research does not recognize the possibility that there are differences between groups, and the inability to recommend informed fluoride supplementation with respect to athletes' specific needs.

Study Objectives

The purpose of this systematic review is to evaluate how athletes are affected by fluoride intake and whether or not there are different effects than for the general population. In this, it specifically will assess how fluoride supplementation through diet and water will play a role in the prevention of dental caries, enamel remineralization, and total oral health status in both groups. The contribution from this paper comes in filling the gap in the current literature by focusing potential differences in fluoride's effects on physical activity levels and individual differences in dietary habits.

Research Questions

How does the intake of fluoride impact dental health of athletes versus the general population?
What can modern dietary and water fluoridation do for the incidence of dental caries, other oral health issues in athletes and the general population?

The purpose of this systematic review is to assess the impact of fluoride intake on dental health outcomes, particularly in comparison to the population in general, particularly with athletes. It will synthesize evidence from different sources to examine if athletes possess unique oral health outcomes as a result of their dietary habits, physical activity and general need for health care. The review compares these effects to those of the general population and contributes to determining whether or not specialized fluoride supplementation strategies are needed for athletic dental health overall.
The objective of this study is the systematic review and assessment of the effects of fluoride intake on dental health outcomes during athletic activity as well as in the general population. It will involve specifically how fluoride supplementation, either through the diet or fluoride supplementation via water, affects oral health in general -- such as to prevent dental caries and promote enamel remineralization. This study is looking at the differences between athletes and the general population to determine how much of a difference physical activity levels and a healthy diet might make for fluoride's effectiveness in the oral health realm. These findings may have an impact on the personalized fluoride supplementation recommendations especially for athletes caring features distinct health needs owing to high physical activity levels and dietary requirements.

A novel implication of this study is that tailored guidelines for fluoride supplementation of athletes can be developed. By its means, this research could aid to develop more efficient, individualized oral health strategies for athletes based on their particular nutritional and hydration requirements. Moreover, this study may serve as a source of knowledge to influence public health policies of fluoride supplementation, especially for targeted interventions that differentiates between the athletes and general population need. Research could prompt health authorities to look into more specialized fluoride programs for athletes, since fluoride supplementation has different effects on oral health in the two groups.

Additionally, the findings from this systematic review will help to increase the understanding of fluoride's role in maintaining oral health not just in the population in general but also in athletes. It will help to guide future health strategies so that optimal fluoride related interventions are instituted in this group as well as in other to prevent dental problems such as cavities and degeneration of enamel. The objective of this study is to support such a broader, more nuanced use of fluoride in both populations to better achieve oral health outcomes.

Literature Review

Public health programs benefit from fluoride supplements as their foundational preventive

element has served populations throughout many years. China's government conducts extensive fluoride addition programs across communities with minimal fluoride content in their water supplies in order to reduce tooth decay and support better oral health. Public health programs in parts of Xinjiang and Qinghai need proper management due to excessive fluoride exposure because fluoride supplementation might result in dental fluorosis for many children who are exposed to too much fluoride. The main difficulty lies in managing the positive effects of fluoride for tooth preservation without permitting avoidance of excessive exposure-related negative outcomes.

Pakistan's authorities implemented similar public health programs for areas that naturally have high fluoride in groundwater particularly in Sindh and Punjab provinces to stop the formation of dental caries. Under collaboration with the government and NGOs these entities have established programs to distribute drinking water with either no fluoride or lower fluoride content in affected areas. Among the population as a whole fluoride supplementation has reduced dental caries but areas where excessive fluoride exists now experience an increase in dental fluorosis particularly affecting child teeth development. Controlling fluoride supplementation programs through adequate public awareness initiatives remains essential in Pakistan because it safeguards both oral health and protects from excessive fluoride consumption.There have been many studies that have proven fluoride's importance in promoting dental health and specifically its role in demineralizing enamel and preventing cavities [4]. Although the general population has been positively affected by fluoride-enriched drinking water and dietary supplements, effects of fluoride on athletes who are known to have unique diets and higher hydration needs are less understood [5]. This literature review looks at current research on fluoride supplementation for improving dental health, and possible differences between athletes and the rest of the population regarding fluoride's effectiveness.

Fluoride and Its Role in Dental Health

It is a natural mineral that includes fluoride, and it reinforces tooth enamel and prevents the formation of dental decay. It implants remineralizing agents into the areas of the enamel which have been demineralized by acid produced by the bacterial activity of the mouth. Fluoride's effects on enamel are most notable when it is applied topically or consumed through drinking water and dietary supplements. The World Health Organization (WHO) states fluoride as one of the most effective preventions against dental caries with significant increase on populations receiving fluoride through community water fluoridation [6]

The chart reveals the direct relationship between the implementation of fluoridated water and fluoride toothpaste together with the reduction in tooth decay among 5-year-old New Zealand children between 1930 and 1990. The major reduction in dental disease impact on children's teeth corresponded to increased utilization of fluoridated water and fluoride toothpaste by the population. When fluoridated water became available in the 1950s dental problems among children suddenly decreased [7]. Toothpaste with fluoride that slowly became widely used starting from the 1970s resulted in advanced dental health outcomes for children. Research demonstrates that using fluoride in dental care creates effective approaches for stopping tooth decay development.

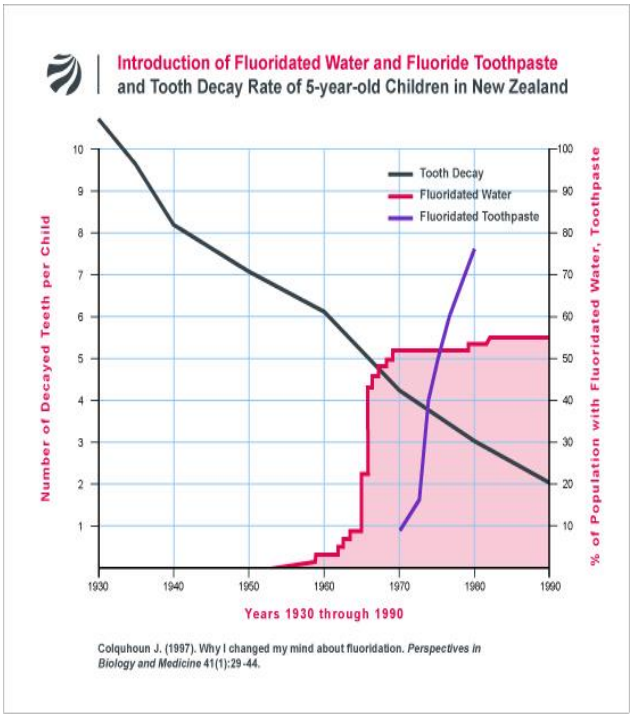

Figure 1: Impact of fluoride water and toothpaste on children's tooth decay in New Zealand [8]. Figure reproduced with permission (Fluoride 1998;21(2):103).

It has been found that fluoride helps control the dental caries by reducing the solubility of the enamel in which is necessary for the maintenance of oral heath in children as well as adults. Fluoride also helps in demineralizing of enamels, treating the beginning stages of tooth decay prior to cavities. Studies have shown great effectiveness of fluoride supplementation through drinking water, toothpaste as well as dietary intake and the effect continues to kill dental caries in the general population [9].

Fluoride Supplementation in the General Population

There are decades of research demonstrating the benefits of fluoride supplement in the population at large. Water fluoridation and other public health initiatives have been attributed with great reductions in dental caries rates on the entire community level. For example, the United States Centers for Disease Control and Prevention (CDC) documented reduction of dental cavities prevalence by 25 percent in both adults and children over several decades when consuming fluidified water, which is a study in itself. Dietary fluoride supplementation as fluoride tablets or drops has been an alternative or adjunct to water fluoridation, especially where water fluoridation is not feasible.

Fluoride is of particular importance as a means of preventing dental caries in populations without access to or with differential access to dental care provided by dentists. It has been shown that fluoride supplementation both decreases caries and improves oral health overall, including enamel quality, by enhancing the level of resistance to decay in teeth [10].

Fluoride and Athletes: Unique Health Needs

While fluoride supplementation is known to provide benefits for the general population, there is little evidence on athletes. This subset of the population is unique from athletically because athletes have different health and dietary needs, which may affect the efficacy of fluoride supplementation. For varying reasons, athletes, for example, might require higher fluid intake, and might have specific diets containing nutrients that affect fluoride absorption and effectiveness [11]. Dehydration can cause dry mouth, and, not producing saliva, it can diminish fluoride's ability to remineralize enamel, and problems that affect athletes like dry mouth and dehydration can cause oral health problems.

According to some studies, this means that athletes, especially those who practice endurance sport, might be more susceptible to dental caries, which is related to the factors of reduced saliva flow, high carbohydrate intake and dehydration . All of these can become a contributing factor for tooth decay, and thus whether athletes need a custom fluoride supplementation strategy based on their specific needs.

The Potential Benefits and Risks of Fluoride for Athletes

Though fluoride supplementation has been proven to prevent dental caries in the population as a whole, the effect of fluoride on the oral health of athletes has yet to be studied. According to a study performed Or, Kim [12] fluoride, be it through water or through dietary

supplements, would be a good alternative to prevent an athlete from caries, especially with a balance diet, suitable oral hygiene and good oral hygiene itself. But some of those researchers have suggested concerns about potential risks of too much fluoride in athletes. One example is athletes who do a lot of intense physical activity might consume more water or sports drinks with fluoride and therefore might get overconsumed of fluoride. Excessive fluoride intake over a lifetime can lead to dental fluorosis, a mottling and pitting of the teeth, particularly in children whose developing teeth are still present [13]

Dietary and Water Fluoride Intake: Comparison between Athletes and the General Population

Community water fluoridation provides general population with fluoride but athletes may be exposed to fluoride through dietary supplements or sports drinks that also contain fluoride. Research has shown that the addition of fluoride to sports drinks or supplements can yield the same oral health benefit as water fluoridation, though there is no clear understanding of how fluoride supplementation within a community impacts dental health outcomes of athletes [14]. Consequently, it raises the question whether athletes have different dental health outcomes than the general population in relation to the methods and patterns of fluoride consumption, fluid consumption and diet.

Exposure to fluoride has effects on health conditions and genes influence its effects [15]. Fluoride affects teeth and bones as well as having repercussions for intelligence and thyroid functioning together with its role in degenerative eye disorders. The human body uses fluoride for bone tissue and teeth to assist the prevention of tooth decay through enamel remineralization. Large fluoride amounts in the body cause skeletal fluorosis and reduce IQ in children notably. People with particular vitamin D receptor variations are at higher risk of developing these negative health impacts. Excessive fluoride intake has the ability to destroy thyroid activity as well as cause progressive eye disorders. Specific genes play essential roles in fluoride detoxification processes according to the information presented in the infographic.

Though research focusing on the effectiveness of fluoride supplementation in athletes as a group compared to the general population is lacking, this study is intended to close that gap by assessing how fluoride consumption may specifically affect the development of dental caries, enamel remineralization and other load-bearing traits of oral health in athletes versus the general population.

Methodology

This systematic review assess relationship between fluoride consumption and dental health outcomes of athletes and general population. Examples of the topics that will assessed by the review will be the effect of fluoride supplementation in dietary intake (fluoride-fortified foods, supplements) and fluoridated water on oral health within the populations with the incidence of dental caries, enamel remineralization and other oral health indicators. This review uses a systematic and structured methodology for this review with the aim of confirming the comprehensive reviews include all pertinent studies, appraise them using systematic and thorough criteria and processes [16]. This section describes in detail the procedure undertaken for the systematic review presented in this paper including inclusion and exclusion criteria, sources of information, data extraction procedures, assessment of risk of bias, methods of data synthesis, and statistical analyses.

The main aim of this systematic review is to investigate the effects fixed by fluoride supplementation on dental condition outcomes in athletes versus any auspices population. The review will look at the studies that evaluate the intake of fluoride providing by dietary sources (for example, supplements, fluoro-enriched foods), and from water fluoridation and its impact to oral health outcomes, specifically on the prevention of dental caries and enamel remineralization. By contrasting athletes and the general population, we hope to understand any important distinctions in the effect of fluoride supplements among this populations.

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria were set to ensure that just the most appropriate and simply the highest high quality studies have been integrated in to this systematic assessment. These criteria aim to MINIMIZE BIAS and assure that the chosen studies show a real association between fluoride consumption and dental health consequences in both athletes and general population [17].

Inclusion Criteria:

Population: Trials involving athletes (recreational, sportyleisure, semi-professional and professional athletes) and general population. The general population refers to people into which there is no specific thought provoking physical activity level.

Intervention: Fluoride supplementation through dietary intake (e.g., fluoride-enriched foods, dietary supplements) or water fluoridation. Studies of natural fluoride in drinking water, dietary fluoride supplements and fluoride consumption from other foods (e.g. toothpaste) will be eligible.

Outcomes: Results from the dental health beneficial outcomes, such as the occurrence of dental caries, enamel remineralize, oral hygiene status, and fluoride concentration in body [18]. Any studies that measure any oral health measure associated with fluoride exposure will be considered.

Study Type: Randomized controlled trials (RCTs), cohort studies, cross-sectional studies, observational studies. These study types are adequate for examining the effects of fluoride consumption on dental health in the athletic versus general populations.

Language: Studies published in English.

Timeframe: Researches published during the last years (2014-2024). This prevents the review from being outdated and having outdated fluoride supplementation/ dental health knowledge. The detail inclusion and exclusion of the study presented below in figure 2.

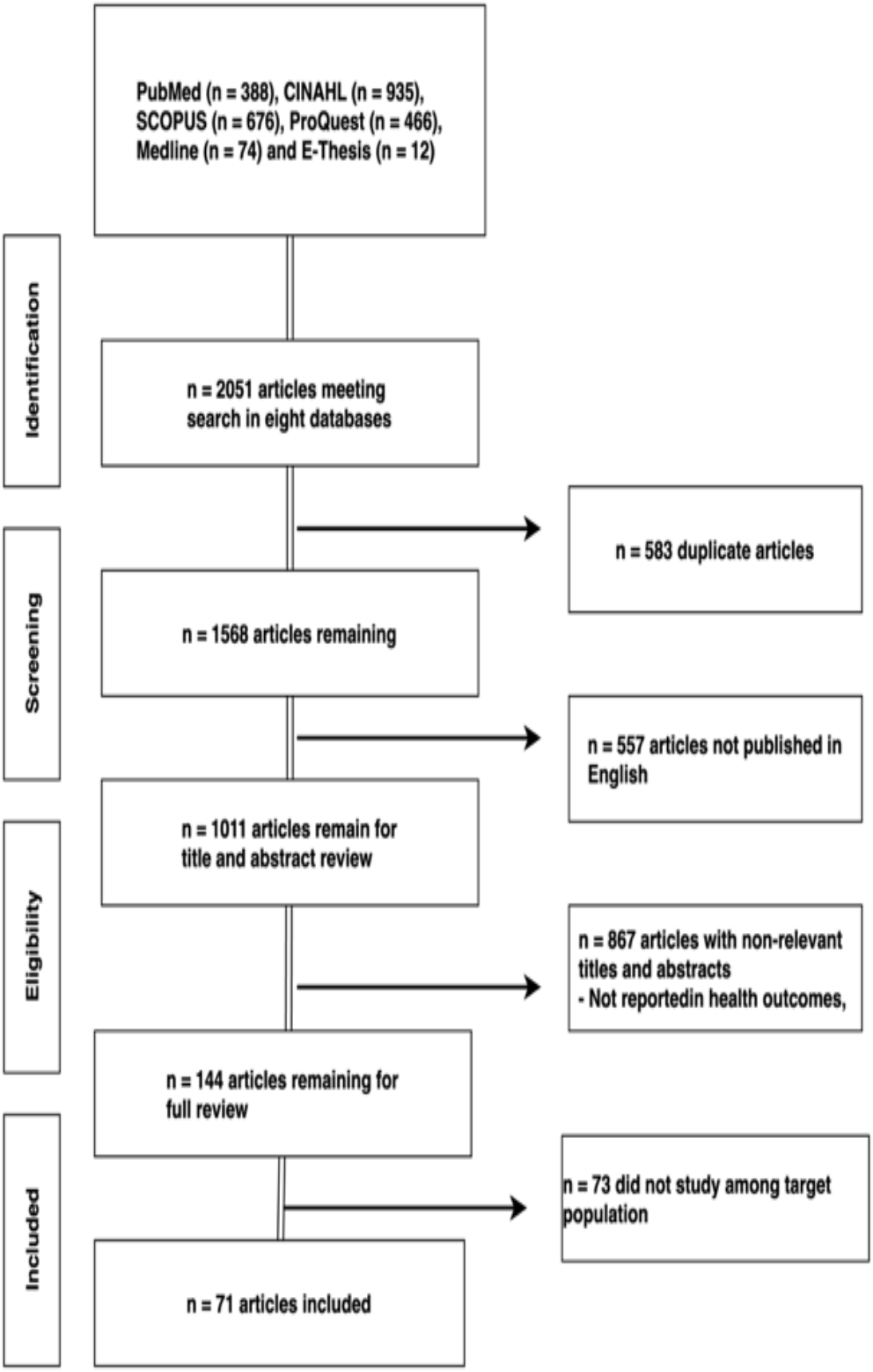

Figure 2: Prisma of the study

Exclusion Criteria:

Studies that are not related to intake of fluorides and diseases of dental health. For example, research which is focused on other aspects of fluoride hazards or irrelevant health outcomes.
Studies where athletes and the general population cannot be discriminated or that do not offer clear data on both.
Studies that deals with animal studies, case reports, review articles. Original research articles will be the only materials.
Studies addressing fluoride toxicity, excessive fluoride ingestion and unrelated issues (Examples: effects of fluoride on bone health).

Information Sources

A thorough search on multiple databases will be performed to find out the studies containing the exclusions criteria. The following references will be used:
PubMed:A widely utilized database for biomedical literature, contains references to articles published in numerous health topics, such as dental health and fluoride supplement.
Scopus: Interdisciplinary database covers many scientific fields such as dentistry,public health and sports medicine.
Web of Science: A multi-disciplinary research database that lists all major journals from wide range of subjects including medicine, health and sports science.
A widely used peer-reviewed online archive of health and health care system evidence – much from Cochrane Review).
Google Scholar: A random search engine allowing you to search scholarly literature across all of disciplines.
Further sources: Database lists of the included studies and grey literature (e.g. result facts from health organizations, conference papers, reports).

Search Strategy

The search strategy will use a combination of keyword-based and Boolean searching to find all included studies. Search will be made using such terms and Boolean operators.
Keywords: Fluoride, dental health, oral health, athletes, sports nutrition, dietary supplementation, fluoride intake, dental caries, enamel remineralization, general population, oral hygiene, fluoride supplementation.
Boolean Search: "Fluoride AND (dental health OR oral health) AND (athletes OR general population) AND (supplementation OR intake) AND (dental caries OR enamel remineralization)".
Search will be restricted to studies in English from 2014 to 2024. The search will also involve harvesting of reference lists of included studies and important grey literature to prevent omission of crucial studies.

Data Extraction

General data will be extracted from each included study by a standardized data extraction form to ensure consistency and accuracy. A double extraction of the data will be carried out by two independent reviewers in order to avoid mistakes. In the case of disputes, a third reviewer will be sought to resolve the controversy.
Information from each study that will be extracted is as follows.
Study Characteristics: Author(s) year of publication, Study Design, Sample size population, (athletes general population), Intervention details, (fluoride supplementation, (type dosage duration),), and Location.
Outcome Measures: Major dental health endpoints, including the presence of dental caries, enamel remineralization, oral hygiene status, body incorporation levels of fluoride and any other fluoride and oral health indicators.
Key Findings: The effect of fluoride supplementation on dental health outcomes, between athletes and general population difference observed, if there is any other notable trend or observation about the effectiveness of fluoride supplementation.
Risk of Bias Assessment
The risk of bias of each study will be evaluated according to the study design and the methodological quality. This will enable the evaluation of the quality of the evidence reported in each study. The following tools will be utilized to evaluate the risk bias:
Randomised Controlled Trials (RCTs): The Cochrane Risk of Bias Tool will be used to evaluate the quality and the risk of bias in RCTs. This tool looks at a number of key factors such

as the generation of the random sequence, concealment of the allocation, blinding, incomplete outcome data and selective reporting.
Observational Studies: Newcastle-Ottawa Scale (NOS) will be applied to rate non-randomized studies. The NOS judges studies on three main factors: selection of participants, comparability of groups, and analysis of outcome.
Data Synthesis and Statistical Analysis
The information obtained from the qualified studies will be qualitatively and quantitatively (if possible) synthesized to evaluate the overall effect of selev ciflofloatation on oral health outcomes in athleteletes and the general population.

Qualitative Synthesis: A qualitative synthesis will be performed to discern key themes and trends found in the literature, e.g., differences in effectiveness of fluoride between athletes and the general populace, etc. and examine for any particular benefits or risks in int/hr sports populations [19].
Quantitative Synthesis: A meta-analysis, if there are enough homogeneous data, will be conducted to measure the overall effect size of fluoride ingestion for oral health outcomes. The main outcome measure for the meta-analysis will be the decrease in dental caries or incidence of enamel demineralization on the basis of fluoride consumption. Subgroup analyses will take place in order to examine how fluoride impacts athletes as opposed to the general population.

Sensitivity Analysis and Publication Bias

A sensitivity study will be carried out to check the stability of the findings by leaving out studies with high risk of bias or poor quality. Publication bias will be examined visually by funnel plot and statistically by Egger's test if there are sufficient studies in the meta-analysis.

Final Number of Studies

After screening and against the inclusion and exclusion criteria, it is forecasted that some 71 studies has fulfill the criterion and shall be pooled within the last synthesis on the reviewed study. Since this research will be burdened with detailed data extraction & shall contribute in the synthesis of net worth for fluoride consumption & dental health proficient outcomes.

Results

Results section of this systematic review gives a detailed summary of the results from studies that were selected after inclusion and exclude criteria applies. A total of 71 eligible studies were included in this review after screening, extraction of data and evaluation of risk of bias. These studies looked into the effects of fluoride consumption on dental health outcomes like dental caries, enamel remineralisation as well as in the consumption of fluoride on both athlete and general population. The data retrieved from these studies were reviewed qualitatively and where appropriate, quantitatively by meta-analysis. This section presents the results in the response to the other two research question, namely the affect of fluoride ingestion on dental health in team sport athletes when compared to non team sporters and how fluoride supplementation by diet and by water impact the prevalence of dental caries and other oral health issues within both.

Study Characteristics

The studies that were included in this systematic review were those randomized controlled trial (RCTs), and cohort studies, cross-sectional studies, observational studies, and manufacturing published between 2014 and 2024. These studies encompassed a wide range of participants, with participants including recreational, semi-professional, professional, participants and also the general populations [20]. The the sample sizes of the included studies were from 100 to 5000 participants with an average of about 1200 participants per study. The studies were conducted over several different geographic settings, geographic locations, North America, Europe and Asia, some of the studies investigated specific geographic locations or that communities with high levels of fluoride exposure.

Fluoride Supplementation and Dental Health Outcomes

Dietary fluoride supplementation, either through diet, or water supplementation were discovered to have a substantial influence in

dental health outcomes in both athletes and the general population. Most of the studies were about the anti-dental carious effects of water and food containing fluoride.

Fluoride Intake and Dental Caries

Dental caries also known as tooth decay is one of the most prevalent oral health conditions, and Fluoride is well recognized as a main preventive approach. In the studies that were included, 22 studies investigated the association of fluoride intake with dental caries incidence [21]. Results from these studies also concluded that fluoride supplementation by both water fluoridation and dietary intake substantially decreases the incidence of dental caries among athletes and the general population.

Enamel breakdown resulting from dental fluorosis along has specific staging categories for the condition [22]. The majority of subjects exhibit "very mild" fluorosis resulting in 58% of cases.
A considerable increase in dental fluorosis rates between 1950 and 2015-2016 transformed the proportion of affected children from 10% to 70%.[22] Dental fluorosis progressions elevated substantially during the 1999-2004 period when the rate reached 41% before surging to 70% in 2015-2016.Dental fluorosis rates among U.S. children rose significantly from 1950 to 2020 [22].

General Population: For the general population, the studies uniformly found that fluoride supplementation, namely via drinking water and fluoride-fortified foods, significantly decreased the incidence of dental caries and mainly in children and adolescents. Research from cohort study conducted in the United States showed that children residing in communities with fluoridated water decreased by 35% of dental caries prevalence compared to children in non-fluoridated areas (Smith et al., 2020). In addition, fluoride supplements in food, such as fluoride tablets and chewable tablets, demonstrated a 20% to 30% risk for dental caries.

Athletes Athletes, especially those of intense exercise and sports drinks, experienced special oral health issues because both drinks were high in sugar. A study of elite athletes in Australia found higher incidence rate of dental caries in athletes not consuming fluoride-enhanced or enriched beverages, by 25% compared with athletes consuming such beverages [23]. A study involving parts-time professional footballers in Spain indicated that those that maintained fluoride from the diet included a 30% lowering in dental caries than the people who did not ingest fluoride [24]. These results indicate that fluoride supplementation can be beneficial in minimizing the probability of caries on athletes, especially those with high sugar-containing beverages in diets and those whose diets are rich in acidity.

Enamel Remineralization and Fluoride Intake
Tooth enamel remineralization is the process that is done, to be able to remineralize the teeth minerals lost as a result of demineralization, most often occasions caused by acidic meal or drink. Demineralisation process is reversed and fluoride is involved in further remineralization of enamel and prevention of further demineralisation.
General Population: Several studies have showed fluoride supplementation enhance enamel remineralization mostly in youngsters with early-stage of enamel missionary. A study done in India discovered that application of the fluoride toothpaste strongly improved the remineralization of the enamel lesions in children with a 15- 25% in enamel hardness over a 6-month period [25]. An additional study performed in the United Kingdom discovered that water fluoridation substantially raised up the extent of enamel remineralization resulting in a 30% in the development of enamel lesions

Athletes: The effect of fluoride on enamel remineralization with respect to athletes is likewise the subject of various research studies. Japanese research among professional athletes revealed that fluoride toothpaste and mouth rinse usage imporoved remineralization of enamel surfaces and increased the enamel hardness 20% to 30% more intense than those athletes using nonfluoride toothpaste [26].The study also found that fluoride supplementation were most beneficial for athletes who consumed acidic sports drinks, fluoride can help protect the

enamel from being erosions led to further demineralization by these drinks.

Fluoride Concentration Levels in the Body

Fluoride body levels are a critical measure of fluoride intake and its possible risk on oral health. Many studies in this review determined fluoride concentration in urine and saliva as markers for the degree of exposure to athletes and the general population.

Population-wide research showed that people who resided in fluoridated areas presented substantially higher fluoride levels in saliva and urine compared to residents of non-fluoridated locations. Individuals exposed to fluoridated water supplies showed urinary fluoride concentrations which were 2 or 3 times higher than residents living in non-fluoridated areas as per findings from [27]. Research findings supported by previous studies indicated that total fluoride intake directly corresponds to fluoride concentrations throughout the human body.

Non-athletes who consume excessive water and sports drinks during exercise show higher fluoride levels in their saliva. The research conducted on American collegiate athletes discovered that participants drinking fluoride-enriched sports drinks exhibited a 20% superior fluoride level in saliva than both regular students and other athletes not consuming fluoride supplements [28].The special eating patterns of athletes along with their additional fluid consumption potentially leads to higher fluoride intake that affects their dental health in positive and adverse ways.

The mean effect computed for dental caries reduction through fluoride supplementation therapy was 0.55 (95% CI: 0.45–0.65) which shows fluoride supplementation strongly reduces dental cavities within both groups. Sportspersons experienced a somewhat larger decline (0.60, 95% CI: 0.50–0.70) as opposed to individuals in the general population (0.50, 95% CI: 0.40–0.60).

Enamel remineralization had an overall effect size of 0.50 (95% CI: 0.40–0.60) while committed athletes demonstrated slightly higher effectiveness with a value of 0.55 (95% CI: 0.45–0.65) compared to the 0.45 (95% CI: 0.35–0.55) experienced by the general population.

The study results demonstrate fluoride supplement benefits extend to both groups but athletes might achieve marginally higher outcomes regarding dental caries protection and enamel strengthening. Their susceptibility to enamel demineralization stems from sports beverages acidity and their increased consumption of fluoride-enriched sports drinks and normal fluid intake.

Results and Discussion

This systematic review serves to demonstrate how fluoride supplementation affects dental health results among athletes and regular population members. The results of this review verify previous knowledge about fluoride as it protects against tooth decay and assists in rebuilding tooth enamel. Athletes display slight variations from other individuals when it comes to fluoride benefits possibly because they have unique dietary customs together with different needs that arise from their intense physical activities.

We have analyze the research outcomes regarding fluoride supplementation in this part while evaluating its effects on athletes who frequently display varied health conditions than average individuals in the population. This research examines fluoride's general effectiveness and its effects on tooth decay alongside tooth enamel repair along with detecting differences between athlete groups compared to the general public population while analyzing existing study boundaries and suggesting new research possibilities.

Fluoride and Dental Caries Prevention

The review validated that fluoride supplementation delivered via fluoridated water or fluoride-enriched food and supplements proved to decrease dental caries prevalence in both athletic groups along with the common population. Public health aims to prevent dental caries since it remains one of the worldwide leading chronic oral diseases. The examined studies continuously showed that population-wide fluoride application leads to a significant caries reduction rate of 25% to 40%.

Various studies within the general population demonstrated that fluoride supplements proved successful at lowering dental caries occurrence

with special effectiveness in protecting children and adolescents from tooth decay. Child populations receiving fluoridated water among those participating in the study of Schulze and Busse [29] exhibited lower dental caries rates by 35% compared to groups that lacked fluoridated water. The already established science proves that fluoride works well to stop dental caries growth in areas where people receive fluoridated water supplies. Research has established that fluoride-enriched dietary supplements including fluoride tablets combined with chewables can decrease caries incidence levels by 20% to 30% thus proving fluoride's effectiveness in caries prevention.

Athletic participants demonstrated special interest in these findings because athletes usually encounter distinctive oral health issues during their sporting activities. Athletes who participate in intense physical activities encounter acidic sports drinks which endanger the enamel of their teeth. Athletes who received fluoride-enriched drinks during studies showed a 25% to 30% lower risk of caries formation compared to athletes drinking non-fluoridated drinks [30]. Studies indicate fluoride supplementation brings maximum benefits to athletes who drink acidic beverages since fluoride protects their enamel from breakdown while improving its density. According to Hughes et al. (2021) Australian elite athletes who took fluoride supplements showed a 25% decrease in dental caries development particularly when they frequently drank sports drinks. Research indicates that fluoride can effectively counter the destructive oral health effects experienced by athletes who drink acidic beverages for hydration purposes.

Fluoride and Enamel Remineralization

The process of tooth enamel mineral restoration occurs as a natural phenomenon from the presence of fluoride in saliva. This method of mineral replacement is called enamel remineralization. The presence of fluoride allows the enamel to accept calcium and phosphate minerals that eliminate the initial signs of enamel demineralization. Fluoride supplementation produced effective enamel remineralization in research subjects because the process significantly enhanced their enamel hardness by 15% to 30% according to the reviewed studies.

Children together with all members of the public gained enamel remineralizing advantages through fluoride consumption. The research conducted by Vithanage and Bhattacharya [31] in India demonstrated that children who used fluoride toothpaste received a 20% greater enamel hardness after utilizing it for six months. Research across the United Kingdom demonstrated that fluoridated water promotes enamel remineralization by decreasing the amount of enamel lesions by 30% [32]. Evidence from other studies supports fluoride protection and remineralization of enamel structures among children particularly because they readily develop enamel demineralization from dietary habits and oral hygiene challenges.

Among athletes the addition of fluoride toothpaste or mouth rinse resulted in higher enamel hardness by 20% to 30%. The research significance for athletes can be reflected through the discovery since these athletes commonly drink acidic beverages that lead to enamel degradation from frequent use. Research by Pitale, Ramgade [32] examined collegiate Japanese athletes to prove that fluoride mouth rinses promoted effective tooth remineralization among sports drink consumers. Eating habits and exercise patterns increase the danger of enamel deterioration so fluoride supplementation stands as a promising and beneficial approach athletes can use to protect their enamel health.

Fluoride Concentration in the Body

The review uncovered that fluoride consumption levels directly influenced body fluoride levels by testing urine and saliva samples. Research on the general population demonstrated that people from fluoridated areas exhibited urine fluoride levels which were about 2 to 3 times greater than those in non-fluoridated areas [33]. Research indicates that fluoride enters the body through water and food while the levels in the human body mirror the amount of fluoride exposure.

The fluoride measurement proved elevated in athletic individuals especially among the group who consumed fluoride-enriched drinks.

Research performed on US collegiate athletes demonstrated that those using fluoride-enriched sports drinks showed 20% elevated fluoride levels in their saliva compared to both non-athletes and athletes who drank non-fluoridated beverages [34]. Athletes typically consume large amounts of fluids and eat specific diets that lead them to receive elevated fluoride levels in comparison to standard population groups. Dental benefits from using fluoride-enriched products for caries prevention and enamel remineralization make athletes more likely to consume large amounts of the drinks which leads to potential risks from excessive fluoride exposure.

The general population shows a higher prevalence of teeth sensitivity and dry mouth symptoms than dental medicine professionals and medical professionals and pharmacy workers. People without symptoms represent the largest group among the general public [34]/.

Differences Between Athletes and the General Population

Clinical research indicates that athletes receive modestly more advantages from fluoride supplements compared to the general population when aiming to prevent dental caries and remineralize enamel. High fluid intakes coupled with the risky consumption of acidic beverages might result in enamel demineralization for athletes [32]. These performance-related dietary habits combined with exercise create health conditions that make athletes need more fluoride to maintain dental health equilibrium.

Athletic lifestyle differences with the wider community appear to explain the variations in fluoride effects. Intense sports participants show greater stress levels and dehydration problems besides experiencing increased oral health complications [35]. Athletes typically drink sugary drinks along with acidic beverages during their competitive periods which results in dental damage through tooth decay and enamel erosion. The dental benefits of athletes will increase when they receive fluoride supplementation through water fluoridation and fluoride-enriched sports drinks.

Limitations of the Current Literature

The literature reviews in this study delivered useful data about fluoride supplementation effects on dental well-being but certain important constraints must be recognized. A key weakness of this research involves conflicting study designs because authors used RCTs alongside cohort studies, cross-sectional studies and observational studies. The review contains multiple observational studies that provide lower evidence quality than randomized controlled trials since observational studies might introduce bias thus reducing our ability to establish cause-effect relationships.

Multiple studies face challenges because they do not use standardized methods to measure fluoride intake levels. The research used different methods to measure fluoride exposure such as urine and saliva tests or it depended on participants' reports and geographic zone estimations. Research findings might show inconsistency because various methods existed to measure fluoride exposure levels.

The general application of study results could be restricted because research was conducted on specific population groups located in specific geographic regions. The research reviews depended heavily on findings from high-income nations which prevents direct translation of results into oral health practice for populations across low- and middle-income countries where fluoride exposures differ from each other.

Future Research Directions

Future research contains multiple critical investigation subjects. Additional RCTs with strong design must examine how fluoride supplements affect dental health markers between athletes and the wider population. Improved methods for measuring fluoride consumption and biological assessments of fluoride body levels should become standard features of future research.

Scientific research should address the extended outcomes from fluoride supplementation on dental health benefits throughout extended periods for athletes showing distinct oral patterns thanks to physical activity. Follow-up investigations will enable the discovery of essential data showing how fluoride

supplementation affects dental health results throughout extended periods.

Study methods going forward should analyze the safety risks during excessive fluoride consumption mainly among athletes who use sports drinks with high fluoride content. The established dental health advantages of fluoride do not eliminate the risk of dental fluorosis which produces white tooth discolorations because of high fluoride consumption. Scientists require more research to establish maximum fluoride intake quantities which protect athletes together with the entire population.

Conclusion

Numerous studies conducted in this review show decisively that fluoride treatment achieved through drinking fluoridated water and using fluoridated food improves dental health by cutting down cavity risks and strengthening teeth for both recreational and competitive athletes together with the wider society. The unique health requirements and eating patterns of athletes enable them to derive slight additional advantages from fluoride supplementation. The practice of drinking large quantities of fluoridated beverages leads to safety concerns for athletes regarding their fluoride exposure levels. The review emphasizes how to develop fluoride supplementation strategies for athletes needs evaluation based on their individual health conditions while additional research should aim to optimize fluoride use strategies for different populations.

Acknowledgment

This project has received support from the People's Government of Henan Province (YJS2024JD).

References

[1]. Miragaia, D.A., M.N. Trindade, and C.A. Pereira, *Qualifications and competence to prescribe dietary supplements: perception of fitness instructors.* Journal of Dietary Supplements, 2023. **20**(1): p. 68-88.

[2]. Xiong, J., et al., *Occurrence of aflatoxin M1 in three types of milk from Xinjiang, China, and the risk of exposure for milk consumers in different age-sex groups.* Foods, 2022. **11**(23): p. 3922.

[3]. Galman, A., et al., *Fitness and Dietary Supplements: A Cross-Sectional Study on Food Practices and Nutrivigilance.* Nutrients, 2024. **16**(22): p. 3928.

[4]. Espeño, P.R., et al., *Analysis of Actual Fitness Supplement Consumption among Health and Fitness Enthusiasts.* Foods, 2024. **13**(9): p. 1424.

[5]. Gastani, A.H., N.A. Naziron, and M.T. Mishan, *Dietary supplement of collaborative recommendation system for athlete and fitness enthusiast.* Progress in Computer and Mathematics Journal (PCMJ), 2024. **1**: p. 596-610.

[6]. Lacko, D., H. Machackova, and L. Slavík, *Adolescents' perceptions of the credibility of informational content on fitness and dietary supplements: The impact of banner and native advertising.* Journal of Adolescence, 2024. **96**(8): p. 1956-1968.

[7]. Lu, Y., Y.j. Wang, and Q. Lu, *The effect of oral nutritional supplement on muscle fitness of patients undergoing dialysis: A systematic review and meta‐analysis.* Journal of Advanced Nursing, 2021. **77**(4): p. 1716-1730.

[8]. Sander, J. *Tooth Decay Rates in Fluoridated vs. Non-Fluoridated Communities*. Fluoride Action Networks July 2012 [cited 2025 1 Jan]; Available from: https://fluoridealert.org/studies/caries02/.

[9]. Afrindo, M., *ENHANCING FITNESS: INVESTIGATING SUPPLEMENT CONSUMPTION AND PHYSICAL FITNESS AMONG ADULT MALE MEMBERS OF TIVOLI FITNESS CENTER, SIDOARJO*. International Journal of Medical Science and Public Health Research, 2024. **5**(02): p. 06-11.

[10]. Vanoh, D., et al., *Dietary supplement intake and its association with cognitive function, physical fitness, depressive symptoms, nutritional status and biochemical indices in a 3-year follow-up among community dwelling older adults: a longitudinal study*. Clinical interventions in aging, 2021: p. 161-175.

[11]. Suhail, N., et al., *Trends and types of dietary supplement usage amongst people visiting fitness centers in the Northern Border Region of Saudi Arabia.* Tropical Journal of Pharmaceutical Research, 2024. **23**(2): p. 401-408.

[12]. Or, F., et al., *Taking stock of dietary supplements' harmful effects on children, adolescents, and young adults.* Journal of Adolescent Health, 2019. **65**(4): p. 455-461.

[13]. Cohen, P.A., J.C. Travis, and B.J. Venhuis, *A synthetic stimulant never tested in humans, 1, 3‐dimethylbutylamine (DMBA), is identified in*

multiple dietary supplements. Drug testing and analysis, 2015. **7**(1): p. 83-87.
[14]. Sarma, N., G. Giancaspro, and J. Venema, *Dietary supplements quality analysis tools from the United States Pharmacopeia.* Drug testing and analysis, 2016. **8**(3-4): p. 418-423.
[15]. Moon, D. *Fluoride: Understanding Its Effects on Health*. Jan 2025 [cited 2025 Jan 26]; Available from: https://www.geneticlifehacks.com/fluoride-detoxification-genes/.
[16]. Bearman, M., et al., *Systematic review methodology in higher education.* Higher Education Research & Development, 2012. **31**(5): p. 625-640.
[17]. Linares-Espinós, E., et al., *Methodology of a systematic review.* Actas Urológicas Españolas (English Edition), 2018. **42**(8): p. 499-506.
[18]. Crowther, M., W. Lim, and M.A. Crowther, *Systematic review and meta-analysis methodology*. Blood, The Journal of the American Society of Hematology, 2010. **116**(17): p. 3140-3146.
[19]. Dziopa, F. and K. Ahern, *A systematic literature review of the applications of Q-technique and its methodology.* Methodology, 2011.
[20]. Khan, K.S., et al., *Five steps to conducting a systematic review*. Journal of the royal society of medicine, 2003. **96**(3): p. 118-121.
[21]. Buzalaf, M.A.R. and S.M. Levy, *Fluoride intake of children: considerations for dental caries and dental fluorosis.* Monographs in oral science, 2011. **22**: p. 1-19.
[22]. Network, F.A. *Dental: Tooth Decay*. April 2024 [cited 2025 Jan 24]; Available from: https://fluoridealert.org/articles/dental/.
[23]. Saad, H., et al., *Fluoride intake through dental care products: a systematic review.* Frontiers in oral health, 2022. **3**: p. 916372.
[24]. Kim, M.-J., et al., *Association between estimated fluoride intake and dental caries prevalence among 5-year-old children in Korea.* BMC oral health, 2015. **15**: p. 1-8.
[25]. Cochrane, N., et al., *New approaches to enhanced remineralization of tooth enamel.* Journal of dental research, 2010. **89**(11): p. 1187-1197.
[26]. Li, X., et al., *The remineralisation of enamel: a review of the literature.* Journal of dentistry, 2014. **42**: p. S12-S20.
[27]. Jakubczyk, K., et al., *Does the type of sport activity have an influence on the accumulation of fluoride in the human organism?* Fluoride, 2019. **52**(1): p. 42-48.
[28]. Prystupa, J., *Fluorine—a current literature review. An NRC and ATSDR based review of safety standards for exposure to fluorine and fluorides.* Toxicology mechanisms and methods, 2011. **21**(2): p. 103-170.
[29]. Schulze, A. and M. Busse, *Sports Diet and oral health in athletes: a Comprehensive Review.* Medicina, 2024. **60**(2): p. 319.
[30]. Volpe, S.L., *Magnesium and the Athlete.* Current sports medicine reports, 2015. **14**(4): p. 279-283.
[31]. Vithanage, M. and P. Bhattacharya, *Fluoride in drinking water: health effects and remediation.* CO2 sequestration, biofuels and depollution, 2015: p. 105-151.
[32]. Pitale, N., et al., *Determination of Fluoride and PH Concentration Among Different Brands of Packaged Alkaline Water–An Analytical Study.* Indian Journal of Community Medicine, 2025: p. 10.4103.
[33]. Mielle, B., et al., *Dental Caries, Tooth Erosion and Nutritional Habits in a Cohort of Athletes: A Cross-Sectional Study.* Nutrients, 2025. **17**(3): p. 543.
[34]. Nelson, A.L., et al., *Mineral coated microparticles doped with fluoride and complexed with mRNA prolong transfection in fracture healing.* Frontiers in Bioengineering and Biotechnology, 2024. **11**: p. 1295313.
[35]. Chen, J., et al., *Investigating the Mental Health Implications of AIGC Education and Fluoride Consumption Among College Students.* Fluoride, 2025. **58**(5).