*International Journal of Paediatric Dentistry* 2001; **11:** 184–192

# Vegetarian children and dental erosion

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**Summary.** *Background.* There have been recent changes in teenage lifestyle and diet. The increasing consumption of soft drinks and foods containing significant acidic components may play a role in the development of dental erosion.
*Objective.* The aims of this investigation were firstly, to assess the prevalence of vegetarian children in a cluster random sample of 14-year-old children in Birmingham, United Kingdom. Secondly, to determine the prevalence of dental erosion in these children, and thirdly, to see if there were any differences between vegetarian and non-vegetarian children in the prevalence of dental erosion and dietary intake.
*Design.* A cluster random sample of 418 14-year-old children (209 males and 209 females) were examined from 12 different schools in Birmingham, United Kingdom; a dietary questionnaire was completed and the levels of tooth wear were recorded using a modification of the (TWI) index. All data were analysed using SPSS with *t*-test and Chi-square analysis. Significance was accepted at the $P < 0{\cdot}05$ level.
*Results.* The results showed that 10% of the children were vegetarian; 52% of them had low dental erosion and 48% moderate dental erosion. Statistically there were no significant differences between vegetarian and non-vegetarian children in the prevalence of erosion; however, there were significant differences in some food and drink consumption.
*Conclusions.* It was concluded that dental erosion is common in teenage children, but there were no significant differences in prevalence between vegetarian and non-vegetarian children.

## Introduction

There is some evidence that the number of young people who avoid eating meat has increased in recent years [1,2]. Fruit and vegetables are excellent sources of complex carbohydrates, dietary fibre, and several vitamins and minerals [3]. Other benefits to health from a vegetarian diet are associated with a decreased risk of cancer of the colon, breast, lung, oral cavity, larynx, oesophagus, stomach, bladder, uterine cervix and pancreas [4]. However, there have been a number of nutritional deficiencies reported amongst vegetarian children such as anaemia [5,6], rickets [7–9], vitamin $B_{12}$ deficiency [10] and slightly restricted growth [11].

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There are few published studies on the prevalence of vegetarianism in teenagers but rather more information about adults. Worsley and Skrzypiec [12] reported on 2000 senior secondary school students from 52 schools in South Australia with a mean age of 16 years; teenage vegetarianism was observed to be primarily a female phenomenon and the prevalence was found to be 8% of girls and 3% of boys.

There are even fewer published studies on the relationship between dental erosion and vegetarianism; Linkosalo and Markkanen [13] found that in adults 26·9% of vegetarians had incipient erosion, 19·2% moderate and 30·8% grave erosion defects, but no erosion was observed in their control group.

A vegetarian diet contains several foods, such as citrus fruits, a number of vegetables including tomatoes, and dried fruits, which have an acidic composition. If these are consumed at high levels

they may be associated with dental erosion. There is growing evidence of a considerable increase in consumption of potentially erosive foodstuffs and drinks [14–16] in the general population, but a scarcity of information on the prevalence of vegetarianism in children and adolescents, and any possible link with dental erosion.

Therefore, the aims of this investigation were firstly to assess the prevalence of vegetarian children in a cluster random sample of 14-year-old children in Birmingham, United Kingdom. Secondly, to determine the prevalence of dental erosion in these children and thirdly, to see if there were any differences between vegetarian and non-vegetarian children in the prevalence of dental erosion and dietary intake.

## Materials and Methods

A total of 418 children were examined from a cluster random sample of 14-year-olds in South Birmingham, United Kingdom; 209 were males and 209 were females. This was as part of the 14-year-old BASCD survey (British Association for the Study of Community Dentistry). In total there were 1988 14-year-old children attending 35 different schools in South Birmingham; 12 of these schools were selected as representative of the social and ethnic mix based on the school postcode. There were 3 girls schools, 3 boys schools and 6 mixed schools. Three of them were grammar schools and nine were comprehensives. Not all of the children were available on the days of the examination; some were not present in school and some children had to leave for specific classes. They, and their parents/carers gave informed consent to participate in this study and ethical approval was given by the Birmingham Research Ethics Committee.

All the children were examined clinically within their schools under standard illumination from a Daray light using number 6 mouth mirrors. The surfaces of all teeth present in the mouth were scored for dental erosion according to the criteria shown in Table 1. This is based on the Tooth Wear Index of Smith and Knight [17] with minor modifications by Millward [18]. These children were examined by the same person (Y.H.A) who had previously undergone extensive training and calibration exercises in this index. The data were recorded by a trained assistant. In case of doubt the lower score was assigned.

Subsequently, after the clinical examination, detailed information was collected through a self-reported questionnaire completed by the children at the schools. There was a wide range of educational attainment and some children required explanation and clarification. A very few children required help to complete the written questionnaire so this was aided by a structured interview with standardised prompts. These questionnaires covered details of medical history, which included gastrointestinal problems such as indigestion, vomiting, heartburn, gastro-oesophageal reflux and the type and frequency of medication. The amounts and frequency of consumption of some types of common drinks and other types of fruit and food were also included in the questionnaire. After the dietary part of the questionnaire the children were then asked if they were vegetarians. Prior to undertaking the study this questionnaire was piloted in three separate studies on children attending the Department of Children's Dentistry and the Department of Orthodontics at the University of Birmingham Dental School and Hospital. Revision and modifications were made subsequently.

The amount of consumption of drinks, food and fruits per week were categorised into the following groups:

- No consumption at all.
- Low consumption (1–7 times per week).
- Medium consumption (8–21 times per week).
- High consumption (22 or more times per week)

In order to determine the prevalence of dental erosion, all the children were classified into one of the following groups based on their individual tooth surface scores. (The incisal edges of maxillary and mandibular anterior teeth and occlusal surfaces of posterior teeth were excluded before categorisation due to the potentially high levels of attrition which would have invalidated measurement of tooth surfaces due predominantly to erosion):

- Any child with scores of only 0 and 1 was placed in the low erosion group
- Any child with at least one score of 2 was placed in the moderate erosion group.
- Any child with at least one score of 3 and/or 4 was placed in the severe erosion group.

All data were analysed using the Statistical Package for Social Sciences (SPSS release Version 8, Chicago, Illinois, USA) with *t*-test and Chi-square analysis. Significance was accepted at the $P < 0{\cdot}05$ level.

**Table 1.** TWI criteria (Smith and Knight, 1984) [17] modified by Millward *et al.* (1994) [18].

| Code: Scores | Surfaces | Criteria |
|---|---|---|
| 0 | B/L/O/I | No loss of enamel surface characteristics. |
| 1 | B/L/O/I | Loss of enamel surface characteristics. |
| 2 | B/L/O | Loss of enamel, visible dentine for less than one third of the surface. |
| | I | Loss of enamel just exposing dentine. |
| 3 | B/L/O | Loss of enamel, visible dentine for > one third of surface. |
| | I | Loss of enamel and substantial loss of dentine but not exposure of pulp or secondary dentine. |
| 4 | B/L/O | Complete loss of enamel, or pulp exposure, or exposure of secondary dentine. |
| | I | Pulp exposure or exposure of secondary dentine. |
| 9 | B/L/O/I | Exclude from analysis (missing tooth, partially erupted, orthodontic band, composite restoration, any crowns, tooth fracture, and fissure sealant). |

B = buccal or labial, L = lingual or palatal, O = Occlusal, I = Incisal.
In case of doubt a lower score is given.

## Results

The results of intra-examiner reproducibility studies gave a rate of (97%) agreement and the weighted Kappa statistic value was 0·91 of 20 children examined. The inter-examiner reproducibility study showed (95%) percentage reproducibility between the two examiners and 0·80 weighted Kappa statistic value of another 20 children examined, which showed a high level of reproducibility in scoring the index.

Of the total of 418 children who were examined clinically and completed the questionnaire, 42 (10%) reported that they were vegetarians; 14 boys and 28 girls (Table 2). The difference between genders was statistically significant ($P < 0{\cdot}004$ Chi-square). The 42 vegetarian children were classified into groups based on their tooth surfaces, excluding incisal and occlusal surfaces. It was found that 52% of vegetarian teenagers had low dental erosion, 48% had a moderate degree of dental erosion confined to visible dentine for less than one third of the surface areas and none of them had severe dental erosion (Table 2). However, there were statistically significant differences between the degree of dental erosion in the number of moderately eroded surfaces in males and females; 64% of males had moderate dental erosion compared to 39% of females ($t = 5{\cdot}745$, $P < 0{\cdot}0001$ *t*-test) and con-

**Table 2.** The prevalence and severity of erosion in 14-year-old, vegetarian and non-vegetarian children.

| | Level of erosion | | | Total | |
|---|---|---|---|---|---|
| Children groups | Low erosion | Moderate erosion | Severe erosion | Number | (%) |
| **Vegetarian children** | | | | | |
| Male (14) | | | | | |
| Number | 5 | 9 | 0 | 14 | 33% |
| (%) of total males | 36% | 64% | 0 | – | – |
| Female (28) | | | | | |
| Number | 17 | 11 | 0 | 28 | 67% |
| (%) of total females | 61% | 39% | 0 | – | – |
| Total males and females (42) | | | | | |
| Number | 22 | 20 | 0 | 42 | 100% |
| (%) of total | 52% | 48% | 0 | – | – |
| **Non-vegetarian children** | | | | | |
| Male (201) | | | | | |
| Number | 90 | 107 | 4 | 201 | 53% |
| (%) of total males | 45% | 53% | 2% | – | – |
| Female (175) | | | | | |
| Number | 90 | 85 | 0 | 175 | 47% |
| (%) of total females | 51% | 49% | 0 | – | – |
| Total males and females (376) | | | | | |
| Number | 180 | 192 | 4 | 376 | 100% |
| (%) of total | 48% | 51% | 1% | – | – |

versely 36% of males had low dental erosion compared to 61% of females ($t = 5{\cdot}745$, $P < 0{\cdot}0001$ *t*-test).

The majority of tooth surfaces showed loss of enamel surface characteristics (score 1) in both upper and lower teeth and labial and lingual surfaces; visible dentine (score 2) was most common on buccal surfaces of anterior teeth.

The results also showed that a total of 376 children (90%) were non-vegetarian; 201 males and 175 females (Table 2). It was found that 48% had low dental erosion, 51% had moderate levels of dental erosion confined to visible dentine for less than one third of the surfaces areas and 1% had severe dental erosion (Table 2). Similarly, as with the vegetarian teenagers there was a statistically significantly difference between the levels of erosion in males and females in non-vegetarian children ($P < 0{\cdot}014$, $P < 0{\cdot}045$ and $P < 0{\cdot}000$ *t*-test) at the low, moderate and severe erosion, respectively). However, there were no statistically significant differences for the prevalence and severity of erosion between vegetarian and non-vegetarian children (*t*-test, $P < 0{\cdot}083$, $P < 0{\cdot}320$. Chi square test, $\chi^2 = 0{\cdot}31$, $P < 0{\cdot}579$).

The data from the questionnaire were also analysed to compare vegetarian and non-vegetarian teenagers. It was found that in the medical history only one child in the vegetarian group had a history of indigestion compared with 18 in non-vegetarian children; also only one child had a history of vomiting compared with 3 children in the non-vegetarian group. For the children who suffered from heartburn and stomach problems, there were two and three children in the vegetarian group compared with 13 and 26 in non-vegetarian children group, respectively. None of these differences were statistically significant.

However, there were significant differences between vegetarian and non-vegetarian children in both food and drink consumption. Figures 1 and 2 show these significant differences. There was a generally high consumption of acidic substances by all the teenage children, particularly in relation to the amount and frequency of consumption of soft drinks, especially carbonated and sport drinks. However, there were no consistent features in the total intake of acidic food and drink between the two groups. For example, although vegetarian teenagers consumed significantly more carbonated drinks, yoghurt, vinegar and salad dressings (Fig. 1), the non-vegetarian teenagers consumed more oranges, sports drinks, beer, cider and pickles (Fig. 2). The *P*-values for these differences ranged from 0·05 to 0·0001 (*t*-test). There was an interesting difference noted in the intake of Vitamin C tablets, which were more likely to be taken by the vegetarian children ($P < 0{\cdot}004$). The difference in the pattern of consumption of drinks and foods between vegetarian and non-vegetarian children were also analysed as shown in Tables 3 and 4. These tables only show those differences that were statistically significant.

## Discussion

There is little published data on the prevalence of vegetarianism in teenage children. The current study involved a cluster random sample of 14-year-olds from a broad range of social and ethnic backgrounds in south Birmingham, United Kingdom. The prevalence of vegetarianism in this group was found to be 10% of teenagers, but with significant differences between genders; 14% of girls were vegetarian compared with 7% boys. This contrast between boys and girls was also observed in the 16–18-year-old Australians reported by Worsley and Skrzypiec [12], although their prevalence of vegetarianism was 8% of girls and 3% of boys.

It has also been noted in the United States that fruit and vegetable consumption is generally greater in girls than boys [19]. However, there is no longitudinal prevalence data, which might indicate whether vegetarianism which is not related to ethnic or religious practices, is increasing amongst the teenage population. This is a very important life-style change, which could have ramifications on a variety of economic and medical considerations.

The overall prevalence of erosion in the current study was slightly higher than reported by Milosevic *et al.* [20]; they observed that 30% of 14-year-olds had evidence of tooth wear. This difference may be due to a number of factors; their study was published 6 years ago and there may have been an increased prevalence over this time period, there may also be differences in examiner calibration and application of the diagnostic index. Additionally, a disparity could be present in other possible aetiological factors such as diet and oral hygiene practices, as well as fluoridation of the drinking water.

In the current study, other aetiological factors such as gastro-oesophageal reflux, vomiting and

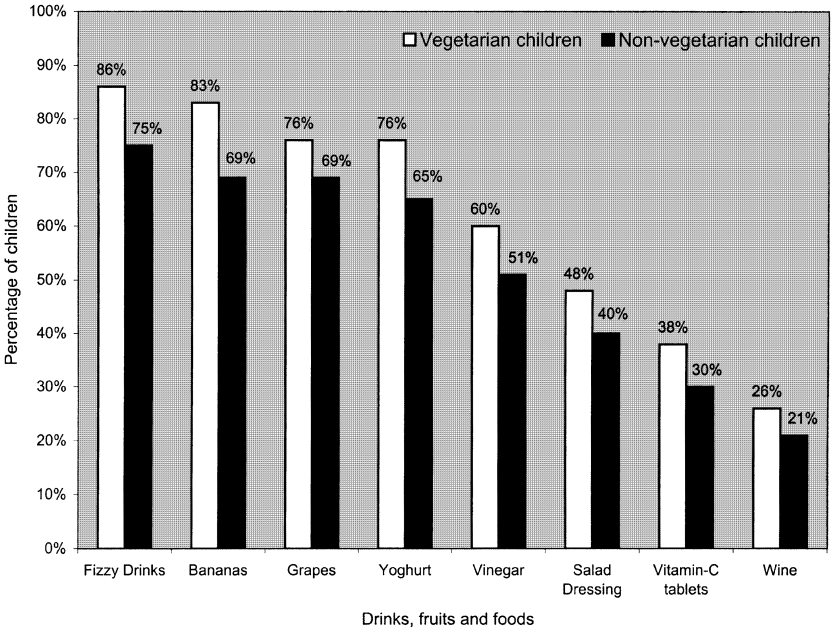


**Fig. 1.** Food and drink consumption: Statistically significantly higher consumption by vegetarian children.

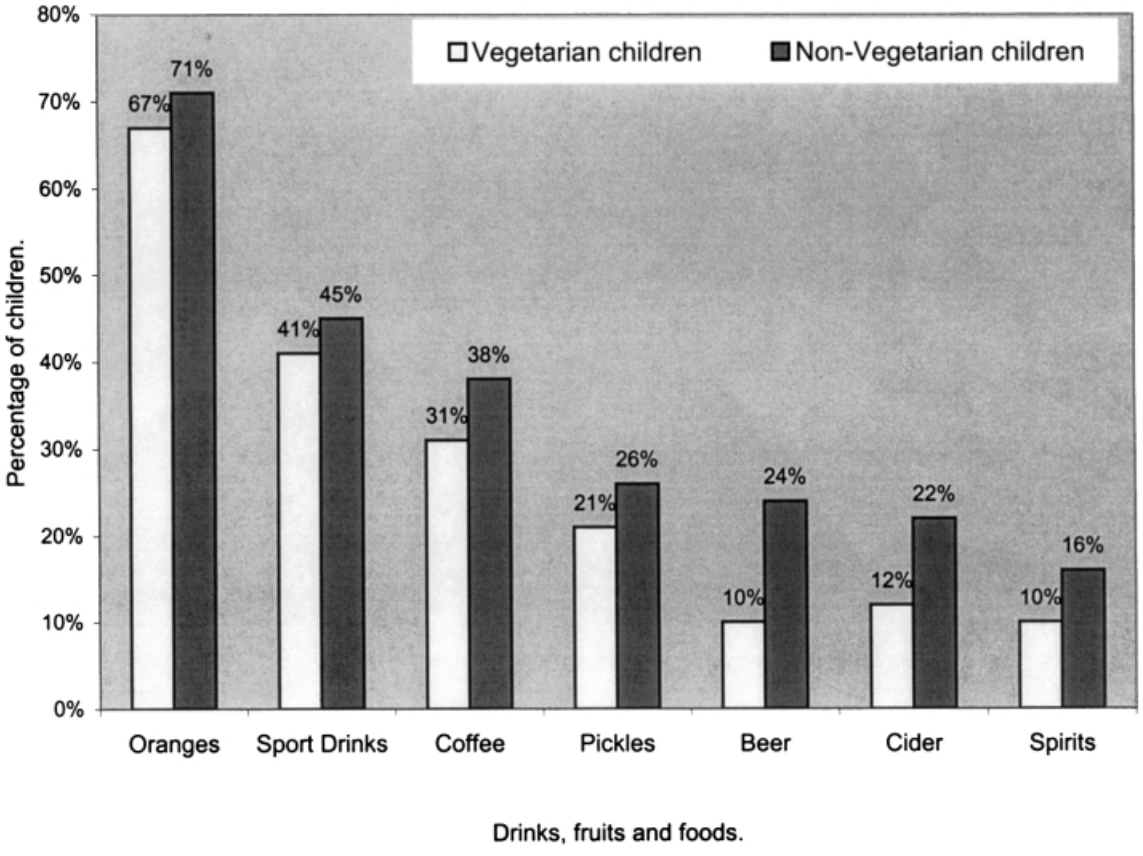


**Fig. 2.** Food and drink consumption: Statistically significantly lower consumption by vegetarian children.

**Table 3.** Statistically significantly higher consumption of drinks and foods by vegetarian children.

| Drinks and foods | Low consumption = 1–7 times per/week | Medium consumption = 8–21 times per/week | High consumption = 22 or more times per/week | Total |
|---|---|---|---|---|
| Fizzy drinks | | | | |
| V | 60% | 19% | 7% | 86% |
| N-V | 45% | 19% | 11% | 75% |
| Bananas | | | | |
| V | 67% | 10% | 6% | 83% |
| N-V | 56% | 11% | 2% | 69% |
| Grapes | | | | |
| V | 61% | 5% | 10% | 76% |
| N-V | 55% | 7% | 6% | 68% |
| Yoghurt | | | | |
| V | 66% | 5% | 5% | 76% |
| N-V | 56% | 7% | 2% | 65% |
| Vinegar | | | | |
| V | 50% | 10% | – | 60% |
| N-V | 45% | 5% | 1% | 51% |
| Salad Dressing | | | | |
| V | 48% | – | – | 48% |
| N-V | 37% | 2% | 1% | 40% |
| Vitamin C-tablets | | | | |
| V | 35% | – | 3% | 38% |
| N-V | 26% | 3% | 1% | 30% |
| Wine | | | | |
| V | 26% | – | – | 26% |
| N-V | 20% | 1% | – | 21% |

V = Vegetarian children and N-V = Non-Vegetarian children.

**Table 4.** Statistically significantly lower consumption of drinks and foods by vegetarian children.

| Drinks and foods | Low consumption = 1–7 times per/week | Medium consumption = 8–21 times per/week | High consumption = 22 or more times per/week | Total |
|---|---|---|---|---|
| Oranges | | | | |
| V | 50% | 14% | 3% | 67% |
| N-V | 61% | 8% | 2% | 71% |
| Sport Drinks | | | | |
| V | 36% | 5% | – | 41% |
| N-V | 33% | 9% | 3% | 45% |
| Coffee | | | | |
| V | 19% | 12% | – | 31% |
| N-V | 23% | 8% | 9% | 38% |
| Pickles | | | | |
| V | 19% | – | 2% | 21% |
| N-V | 23% | 2% | 1% | 26% |
| Beer | | | | |
| V | 10% | – | – | 10% |
| N-V | 21% | 3% | – | 24% |
| Cider | | | | |
| V | 8% | 4% | – | 12% |
| N-V | 19% | 2% | 1% | 22% |
| Spirits | | | | |
| V | 10% | – | – | 10% |
| N-V | 15% | 1% | – | 16% |

V = Vegetarian children and N-V = Non-Vegetarian children.

other gastro-intestinal disorders were also considered. However, there were no significant differences between the vegetarian and non-vegetarian children.

Analysis of the detailed dietary history indicates a very high intake of acidic dietary components in all children. Soft drinks were consumed on a frequent

basis but there were significant differences between the vegetarian and non-vegetarian teenagers. For example, carbonated drinks were regularly consumed by 86% of vegetarians compared with 75% of other children. However, the non-vegetarians consumed significantly more sport drinks and alcoholic drinks such as beer, cider and spirits.

It was also noted in this current investigation that almost 40% of vegetarian children were taking Vitamin C tablets and some case reports have shown an association between erosion and chewing Vitamin C preparations [21–23]. These findings support the relationship between Vitamin C tablet intake and dental erosion, and emphasise possible risks.

Alcohol consumption is a sensitive issue in young teenagers; the present study showed that a quarter of them regularly consumed alcohol in some form. It was stressed to the participants in this study that all the questionnaires and interviews were entirely confidential and the results would not be divulged to anyone. The data are therefore likely to be a reasonably honest evaluation of alcohol consumption. There is a known association between alcohol and gastro-oesophageal reflux [24] and therefore the possibility exists that both the direct acidic contact of these drinks as well as the later indirect acidic reflux may contribute to the development of erosion. Alcohol consumption in children in the USA has been reported as 7·7% in a recently published study [25] but direct comparison of figures is difficult.

There were also differences in fruit consumption between vegetarian and non-vegetarian children but significantly more citrus fruits such as oranges were consumed by the latter group. There has been increasing pressure from nutritionists in recent years to place more emphasis on fruit and vegetable ingestion in children. Recent intervention programmes aimed at increasing consumption have been undertaken amongst adolescents in the United States [26,27]. They have involved media campaigns, classroom workshops, school meal modification and parental support. Some of these programmes have commented on the high consumption levels of cola-type, other soft drinks, carbonated beverages and sport drinks, at the expense of more nutritious food and drink. There has also been a relationship shown with the development of dental erosion [28–31].

The results from these UK teenage vegetarians did not confirm those from the study by Linkosalo and Markkanen [13] who showed higher levels of erosion in lactovegetarians. However, their investigation involved only 26 Finnish subjects with a mean age of 39·6 (S.D $\pm$ 10·2) and very different habits of food and drink consumption. Both vegetarian and non-vegetarian children in the current study had very high consumption of acidic dietary components.

Thus, the results from the present study have shown relatively high levels of erosion and significant correlation of this with acidic dietary components. The prevalence of vegetarianism in this cluster random sample of 14-year-olds was 10%, but with significantly more girls (14%) than boys (7%). There was no significant difference in the levels of dental erosion in vegetarian and non-vegetarian teenagers. However, on detailed dietary analysis it is apparent that the diets of both these groups of children were acidic, but from different sources and with no degree of consistency. Although, overall there was a relationship between acidic food and drink consumption and erosion, it is not vegetarianism as such that is the explanation. The high consumption of acidic foods by the teenagers should be given greater emphasis in order to reduce and prevent the development of dental erosion. The dietary variables are plainly complex but it may be that drink consumption, whether part of a vegetarian or non-vegetarian diet is an important aetiological factor.

**Résumé.** *Arrière-plan*. De récents changements sont apparus dans le régime alimentaire et le style de vie des jeunes sujets. Une consommation croissante de boissons et aliments sucrés (contenant des composants acides significatifs peut jouer un rôle dans le développement d'érosions dentaires.
*Objectif*. Cette étude a eu pour objectifs d'évaluer dans un premier temps la prévalence de sujets végétariens dans un échantillon randomisé (d'enfants de 14 ans de Birmingham, Royaume-Uni. Deuxièmement, de déterminer la prévalence d'érosions dentaires chez ces enfants, et troisièmement de voir s'il existait des différences entre les enfants végétariens et non végétariens au niveau de la prévalence des érosions dentaires et la prise alimentaire.
*Protocole*. Un échantillon randomisé de 418 enfants de 14 ans (209 garçons, 209 filles) a été examiné dans 12 écoles différentes de Birmingham, Royaume-Uni; un questionnaire de diététique a été rempli, et les

indices dentaires ont été répertoriés à l'aide d'un indice (TWI) modifié. Toutes les données ont été analysées à l'aide de SPSS, en utilisant les analyses par test t et chi deux. La significativité a été acceptée à $p < 0{,}05$.
*Résultats*. Les résultats montrent que 10% des enfants sont végétariens; 52% d'entre eux avaient une faible érosion dentaire, et 48% une forme modérée. Il n'y avait pas de différence statistique entre les enfants végétariens et non végétariens au niveau de la prévalence des érosions; il y avait cependant des différences significatives pour la consommation de certaine nourriture et boisson.
*Conclusions*. L'érosion dentaire est commune chez les adolescents, mais il n'y a pas de différence significative dans la prévalence entre les enfants végétariens et non végétariens.

**Zusammenfassung.** *Hintergrund*. In den letzten Jahren haben sich Lebensstil und die Ernährung von Kindern verändert. Zunehmender Konsum von Softdrinks sowie Nahrungsmitteln mit nennenswertem Säuregehalt können eine Rolle spielen in der Entstehung von Zahnerosionen.
*Ziele*. Die Ziele der Untersuchung waren zunächst das die Feststellung der Prävalenz vegetarische Ernährung von Kindern in einem Kollektiv Vierzehnjähriger in Birmingham, UK. Weiterhin sollte die Prävalenz von Zahnerosionen ermittelt werden und schließlich Unterschiede gesucht werden zwischen Kindern mir vegetarischer und nichtvegetarischer Ernährung hinsichtlich der Nahrung und dentaler Erosionen.
*Studienanlage*. Eine Zufallsstichprobe von 418 Vierzehnjähriger (209 männlich und 209 weiblich) aus 12 verschiedenen Schulen aus Birmingham, UK, wurde untersucht; ein Ernährungsfragebogen wurde ausgefüllt und das Ausmaß der Zahnerosionen wurde registriert unter Verwendung einer Modifikation eines Index (TWI). Alle Daten wurden unter Zuhilfenahme von SPSS mittels t-Test und $\chi^2$-Test analysiert. Als Signifikanzniveau wurde festgelegt $p < 0.05$.
*Ergebnisse*. Die Ergebnisse zeigten einen Anteil von 10% Vegetariern; von diesen wiesen 52% geringe und 48% mäßige Zahnerosion auf. Es zeigten sich keine statistisch signifikanten Unterschiede zwischen Vegetariern und Nichtvegetariern hinsichtlich der Erosionen. Allerdings lagen signifikante Unterschiede vor im Konsum bestimmter Nahrungsmittel und Getränke.
*Schlußfolgerungen*. Es kann gefolgert werden, daß Erosionen bei Jugendlichen nicht selten sind, signifikante Unterschiede zwischen Vegetariern und Nichtvegetariern konnten jedoch nicht gezeigt werden.

**Resumen**. Ha habido cambios recientes en el estilo de vida y la dieta de los adolescentes. El incremento en el consumo de refrescos y alimentos con alto contenido de componentes ácidos, puede intervenir en el desarrollo de erosiones dentales.
*Objetivos*. Los objetivos de esta investigación fueron: primero, identificar la prevalencia de niños vegetarianos en una muestra al azar de niños de 14 años en Birmingham, Reino Unido. Segundo, determinar la prevalencia de erosión dental en estos niños y tercero, verificar diferencias entre niños vegetarianos y no vegetarianos en la prevalencia de erosión dental y hábitos dietéticos.
*Diseñ*. Se evaluó una muestra elegida al azar de 418 niños de 14 años, (209 varones y 209 mujeres), de 12 diferentes colegios de Birmingham, Reino Unido. Se completó un cuestionario dietético y se registraron los niveles de erosión dentaria usando una modificación del Indice de TWI. Toda la información se analizó mediante SPSS, utilizando el test de la Chi cuadrado y el test de la t. El nivel de significación se aceptó para una $p < 0.05$.
*Resultados*. Los resultados mostraron que el 10% de los niños evaluados eran vegetarianos; 52% de ellos tenían una erosión dental baja, y 48% moderada. Estadísticamente no hubo diferencias significativas entre niños vegetarianos y no vegetarianos en la prevalencia de erosión; sin embargo se encontraron diferencias significativas en el consumo de algunos alimentos y bebidas.
*Conclusiones*. Se concluyó que la erosión dentaria es común en adolescentes, pero no se encontraron diferencias significativas en la prevalencia entre niños vegetarianos y no vegetarianos en cuanto a esta condición.

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