



Original/*Valoración nutricional*

School dietary habits and incidence of dental caries

Celia Monteagudo¹, Francisco Téllez¹, Leticia Heras-González¹, Diana Ibañez-Peinado¹, Miguel Mariscal-Arcas^{1,2} and Fátima Olea-Serrano¹

¹Department of Nutrition and Food Science, Research Group Nutrition, Diet and Risk Assessment (AGR-255), University of Granada. ²Department of Food Technology, Nutrition and Food Science, University of Murcia. Spain.

Abstract

Introduction: healthy dietary habits are considered to improve oral health and tooth quality. Caries treatment comprises tooth restoration with dental composites and sealants, almost all (>90%) of which contain bisphenol A (BPA). Study hypotheses were: a) breakfast and oral hygiene habits are important factors in dental caries development; and b) dental caries treatment with epoxy-resins entails a risk of oral exposure to monomers migrating from the polymeric material. We evaluated caries in the teeth of a Spanish school population and determined the percentage treated with dental composites.

Objective: to relate consumption of breakfast components and oral hygiene habits to dental caries and determine the presence of sealants/composites as potential sources of BPA exposure.

Methods: subjects: 582 schoolchildren from Granada city (Southern Spain) aged 7 yrs; mean (SD) of 7.55 (0.64) yrs.

Results: caries was detected in 21.7% of their teeth. Mean breakfast quality index (BQI) score, based on nutritional questionnaires, was 5.18 (1.29). Breakfast with foods rich in simple sugars representing > 5% of total daily energy was consumed by 24% of the population and was significantly associated with caries frequency in binary logistic regression analysis. Biscuit consumption was reported by 35.8% and significantly associated with caries frequency. Breakfast intake of bakery products/cereals and of dairy products showed a significant inverse association with caries frequency. No significant relationship was observed between caries and BQI score or oral hygiene factors.

Conclusion: further research is required to elucidate the role of diet in caries and the associated risk of exposure to estrogenic xenobiotics such as BPA.

(Nutr Hosp. 2015;32:383-388)

DOI:10.3305/nh.2015.32.1.9086

Key words: *Dental caries. School dietary. Breakfast. Dental composites.*

HÁBITOS DIETÉTICOS DE LOS ESCOLARES E INCIDENCIA DE CARIES DENTAL

Resumen

Introducción: los hábitos alimentarios saludables influyen sobre la salud oral. El tratamiento de la caries comprende la restauración dental con selladores y composites dentales, la mayoría con bisfenol A (BPA). Hipótesis: a) el desayuno y hábitos de higiene oral son factores importantes en el desarrollo de caries; b) el tratamiento de la caries con epoxirresinas conlleva riesgo de exposición oral a monómeros plásticos.

Objetivo: relacionar la ingesta del desayuno y los hábitos de higiene oral con la caries dental y determinar la presencia de selladores/composites como fuentes potenciales de exposición al BPA.

Métodos: se analizaron 582 niños/as en edad escolar de Granada (sur de España) de 7 años de edad (7,55 [0,64] años). Se empleó un cuestionario de frecuencia de consumo de alimentos, 3 recordatorios de 24 h y variables de estilo de vida, incluyendo la higiene bucodental. La calidad del desayuno fue estimada con el *Breakfast Quality Index* (BQI).

Resultados: se detectó un 21,7% de caries. El valor medio del BQI fue 5,18 (1,29). El 24% de la población realizó un desayuno con alimentos ricos en azúcares simples (>5% de la energía total), asociado significativamente con la frecuencia de caries en el análisis de regresión logística. El 35,8% de los participantes tomaron galletas; asociado significativamente con la frecuencia de caries. La ingesta de productos de panadería, cereales y lácteos mostró una asociación inversamente significativa con la frecuencia de caries.

Conclusión: se necesitan más investigaciones para aclarar el papel de la dieta en la caries y el riesgo de exposición a xenobióticos estrogénicos, como el BPA.

(Nutr Hosp. 2015;32:383-388)

DOI:10.3305/nh.2015.32.1.9086

Palabras clave: *Caries dental. Dieta escolar. Desayuno. Composites dentales.*

Correspondence: Fatima Olea-Serrano.
Department of Nutrition and Food Science,
University of Granada.
Campus de Cartuja s/n. 18071 Granada (Spain).
E-mail: folea@ugr.es

Recibido: 8-IV-2015.
Aceptado: 27-IV-2015.

Introduction

The acquisition of adequate dietary habits during childhood can be vital to achieve optimal growth and health status. A correct diet includes a healthy breakfast that provides 20-25% of the total daily energy intake and is characterized by the presence of cereals, dairy products, fruit, a reduced amount of simple sugars, and a healthy lipid profile^{1,2}. This favors cognitive performance in school tasks and adequate physical activity during the morning³.

Healthy dietary habits in the early years of life are considered to improve oral health and tooth quality. Dental caries is a multifactorial disease characterized by the destruction of tooth tissues due to demineralization from the acids generated by bacterial plaque⁴. Dental caries has been associated with underprivileged family situations, nutritional imbalances, and poor oral hygiene techniques, including, lack of tooth brushing or dental flossing, and it also has a genetic etiology^{5,6}. It was recently reported that a nutritionally adequate supply of Vit. D and calcium (Ca) is important for oral health⁷, and some authors have recommended fluoride supplementation together with an optimal Vit. D supply⁸. Tooth destruction is associated with the intake of sugars and acids in drink and food. The saliva pH has also been related to caries⁶.

Pits and fissures favor plaque retention, and sealants have been developed to prevent caries in these areas. They create a physical barrier that isolates these surfaces from the oral medium, impeding the accumulation of bacteria and organic remains and blocking the supply of nutrients to microorganisms that are present. Caries treatment consists in removing the infectious agent and affected dental tissues and restoring or rehabilitating the tooth with dental composites and sealants. Virtually all (>90%) composites and sealants contain bisphenol A (BPA). The most widely used material is bisphenol glycidyl methacrylate (bis-GMA) resin^{9,10}.

Some monomers of these composites, especially BPA, were observed to mimic the effect of estrogen hormones *in vivo*¹¹⁻¹³. BPA has also been associated with obesity, diabetes, and abnormalities in liver enzymes¹⁴. After reviewing different studies, the European Food Safety Authority¹⁵ concluded that exposure to BPA may be associated with effects on kidneys, liver, and breast glands in animals. The current tolerable daily intake (TDI) is 0.005 mg/kg body weight/day, but this is a temporary value until more definitive results are obtained from a current study under the US National Toxicology Program¹⁶.

The working hypotheses of the present study were: a) breakfast and oral hygiene habits are important factors in dental caries development; b) dental caries treatment with epoxy-resins entails a risk of oral exposure to monomers migrating from the polymeric material. In this preliminary research, we assessed the degree of caries in a school population and determined the per-

centage of schoolchildren treated with dental composites. The objective was to relate the consumption of breakfast components and oral hygiene habits to dental caries and determine the presence of sealants and composites as potential sources of exposure to BPA.

Methods

The sample comprised 582 schoolchildren from the city of Granada (Southern Spain) aged 7 years (mean age of 7.55 yrs (SD: 0.64 yrs)). Participating schools were randomly selected from different neighborhoods of the city. Experienced and specifically trained interviewers administered each participant with a validated semi-quantitative FFQ, 3 x 24 h recall, and questionnaire on food habits and lifestyle, including oral hygiene practices^{17,18}. Data from the nutritional questionnaires were used to estimate the breakfast quality index (BQI)². The food composition tables in the DIAL 1.19 software program used in this study were reviewed, checking the nutrient composition of each food against the data in the program and ensuring the inclusion of all nutrients of interest or in the usual diet of the study population^{19,20}. The reference data were based on dietary recommendations for this population in Spain and those published by international bodies²¹. The presence of caries, dental composites, and sealants in the study population was assessed by a single dentist in the school. This study was approved by the Ethics Committee of our institution, and written consent was obtained from the parents/guardians of the participants.

Statistical Analysis

Analyses were stratified by sex. Continuous variables were expressed as means, maximum, minimum, and standard deviation (SD). Student's t-test was used to compare means of variables. Categorical variables were expressed as frequencies and analyzed with the chi-square test. Logistic regression analysis was used to establish the likelihood of having caries as a function of the study variables. $P < 0.05$ was considered significant. SPSS version 20.0 (IBM, Chicago, IL) was used for all statistical analyses.

Results

Table I lists the characteristics of the study population, including variables related to oral hygiene and habits related to possible tooth damage. Significant differences between males and females were observed in tooth brushing after meals, the person who taught them oral hygiene practices, nail-biting, thumb-sucking, and bruxism habits.

There was a significantly higher ($p = 0.005$) frequency of caries in maxilla (12.0 SD: 7.2) than in mandi-

Table I
General characteristics of the study population

	Total population (n=582)	Male (n=281)	Female (n=301)	P
Age (yrs)	7.55 (0.64)	7.57 (0.66)	7.54 (0.61)	0.400
Do you brush your teeth after meals (Yes)	75.7	73.0	77.5	0.048
Do you brush your teeth at school (Yes)	9.4	9.9	9.0	0.394
Mouthwashes with fluoride (Yes)	36.4	37.6	36.2	0.531
Dental braces (Yes)	10.5	12.1	8.2	0.102
Latest visit to the dentist				
< 3 months	31.8	32.0	31.7	
3 months- 1 year	16.3	17.3	15.4	0.066
> 1 year	11.3	12.7	8.7	
Never	40.6	38.1	44.2	
Why?				
Revision	43.7	43.6	43.1	
Cleaning	19.2	19.5	19.1	
Caries	6.8	7.4	6.5	0.918
Sealant	7.9	8.3	7.4	
Disease	3.9	4.0	4.0	
Fracture	18.4	17.2	20.0	
Tooth brushing frequency				
3 times/day	37.4	34.2	40.4	
2 times/day	22.4	22.3	22.6	
Once/day	24.5	26.0	23.0	0.202
Sometimes (not daily)	13.7	15.1	12.2	
Never	2.0	2.4	1.8	
Who taught you to brush your teeth?				
Home	59.5	55.5	62.7	
School	0.9	0.8	0.6	0.004
Dentist	13.4	11.9	14.9	
Other	26.2	31.8	21.9	
Type of toothpaste				
None	2.2	3.1	1.0	
Specific for children	63.9	59.3	69.1	0.001
The one there is at home	33.7	37.6	30.0	
Habits				
Nail biting	26.7	24.0	28.9	
Thumb-sucking	5.2	4.2	6.1	0.024
Bruxism	8.4	10.5	6.5	
None	59.6	61.3	58.4	
Caries frequency				
No teeth with caries	53.1	56.9	52.8	
1-3 teeth with caries	22.6	19.7	22.1	0.765
> 3 teeth with caries	24.3	23.4	25.2	
Treatment frequency				
No treated teeth	41.0	37.2	42.6	
1-3 treated teeth	27.8	28.9	26.6	0.696
> 3 treated teeth	32.0	34.0	30.0	

ble (9.6 SD: 9.6) but a larger percentage of sealants or composites in the mandible than in the maxilla (12.4 SD:11.5 vs. 8.9 SD: 5.4).

The mean BQI value was 5.18 (1.29), with no significant difference in mean score between the sexes. At breakfast, significantly more dairy products were

consumed by the girls than by the boys, implying a higher Ca intake (Table II). Breakfast included foods rich in simple sugars that represented > 5% of total daily energy in 24% of the population and was associated with a higher frequency of caries. Biscuits were consumed at breakfast by 35.8% and were also asso-

ciated with a higher frequency of caries. In the binary logistic regression analysis, caries frequency was not significantly related to the BQI score ($p=0.753$) but showed a significant association with the consumption of breakfast cereals and an inverse association with the intake of dairy products (Table III). No significant relationship was observed between oral hygiene factors and dental caries.

Discussion

Caries affected 21.7% of the teeth of this sample of 582 young schoolchildren from Southern Spain with a mean (SD) age of 7.55 (0.64) yrs, similar to recent findings of a prevalence of 26-34% in 6-year-old Spanish and USA Children^{22,23} but lower than earlier observations of 35.4% in the same age group in 2002 and confirming reports of a substantial reduction in caries prevalence in 6-year-olds since 1997²⁴. In the present series, between one and three teeth were treated with composites or sealants in 29% and more than three tee-

th in 32%. Various authors have described a similar frequency of sealants and have contrasted the potential benefits of their application with their well-documented release of BPA²⁵⁻²⁸. There is increasing interest in the *in vivo* release of sealant components, including BPA, which have estrogenic effects, and further research is recommended to analyze the accumulative estrogenic effects of BPA in dental sealants²⁹ and their long-term impact³⁰.

Despite the trend towards a lower prevalence of dental caries in developed countries, it is increasing in some developing countries under nutritional transition⁵. There is convincing evidence of an association between dental caries and the amount and frequency of free sugar intake⁶. Although other fermentable carbohydrates may not be completely innocuous, epidemiologic studies show that the consumption of necessity foods, including starch and fresh fruit, is associated with low levels of dental caries. It has been reported that the incidence of dental caries is low when free sugar consumption is lower than 15-20 kg/yr (around 6% of energy consumption). It is recommended to

Table II
Percentage of participants that meet the premises of quality breakfast (BQI) within the Mediterranean Diet context

BQI-items	Total	Boys	Girls	p*
1. Cereals and derivatives (bread breakfast, cereals, bakery products)	83.3	82.3	84.3	0.412
2. Fruit and vegetables (fruit, fruit juice, vegetables)	22.1	23.8	20.5	0.179
3. Dairy products (whole and semi-skimmed milk, milkshake, yoghurt, cheese)	83.7	81.2	86.3	0.020
4. Foods rich in simple sugars (sugar, jam, honey) <5% of total daily energy	77.0	75.8	78.2	0.330
5. MUFA-rich fats (olive oil, vegetable oil)	15.2	15.5	14.9	0.797
6. MUFA/SFA > median	53.2	55.6	50.8	0.129
7. Compliance with energy intake recommendations (20-25% of total daily energy)	15.8	14.6	17.0	0.261
8. Cereals + fruit + dairy product in same meal	9.1	10.3	7.9	0.154
9. Calcium (200-300 mg)	46.6	43.0	50.2	0.014
10. Absence of SFA- and trans-rich fats (butter, margarine)	74.5	73.1	75.8	0.305
BQI: mean value (SD)	5.18 (1.29)	5.14 (1.30)	5.23 (1.28)	0.238**

*Chi-squared test, **t test

Table III
Factors of a healthy breakfast that affect caries frequency

Food of breakfast	B	p	OR	95% CI	
				Lower	Upper
Cereals and derivatives (bread, breakfast cereals, bakery products)	-1.028	0.026	0.358	0.144	0.886
Dairy products (whole and semi-skimmed milk, milk shake, yoghurt, cheese)	-1.101	0.025	3.006	1.15	7.86
Simple sugars > 5% of total daily energy	0.496	0.034	1.642	1.039	2.596
Biscuits	0.411	0.057	1.509	0.988	2.305
Calcium (200-300 mg)	-0.621	0.065	0.537	0.259	1.014

reduce the amount of free sugars, with a maximum recommendation of $\leq 10\%$ of the total daily energy intake, according to the EFSA³¹. It has also been proposed that foods containing free sugars should not be consumed more than 4 times a day⁶. In the present study, the consumption at breakfast of foods rich in simple sugars that represented more than 5% of total daily energy was associated with dental caries (Table III). Dairy products are an important source of micronutrients, e.g., Ca, phosphorus, magnesium, zinc, vitamin A, vitamin D, and riboflavin. Dairy products also provide children with energy, quality proteins, and essential and non-essential fatty acids. In the present study, the consumption of dairy products and Ca estimated in the BQI of this population were found to be protective dietary components against dental caries (Table III). These findings are consistent with a recent report of a non-significant or inverse association of milk or dairy product consumption with adiposity indicators, dental caries, and hypertension in children and adolescents³².

This study confirms that an inadequate diet rich in free sugars is a key factor in the development of caries. Treatment of this disease with polymeric material risks the release of BPA into the oral cavity, mainly into the saliva. The next stage in the present research project will be to measure BPA in the saliva and urine of schoolchildren to quantify their exposure to this compound, which is known to exert estrogenic actions among other undesirable effects. Mixed, basic, clinical, and epidemiologic studies are required to elucidate the true impact on human health and healthcare costs of human exposure to estrogenic xenobiotics.

Acknowledgements

The authors are very grateful to the participants and their families who gave their time to the study. They also thank Richard Davies for his assistance with the English version. This is a joint project between research group AGR255 and Granada City Council (health area) contract C-3507-00, Granada City Council-Universidad Empresa. This work was supported by grants from the Spanish Ministry of Health (FIS, - PI14/01040).

References

1. WHO, 2003 (<http://www.who.int/whr/2003/es/>).
2. Monteagudo C, Palacín-Arce A, Bibiloni Mdel M, Pons A, Tur JA, Olea-Serrano F, Mariscal-Arcas M. Proposal for a Breakfast Quality Index (BQI) for children and adolescents. *Public Health Nutr* 2013 Apr;16(4):639-44. doi: 10.1017/S1368980012003175.
3. Chaddock-Heyman L, Hillman CH, Cohen NJ, Kramer AF III. The importance of physical activity and aerobic fitness for cognitive control and memory in children. *Monogr Soc Res Child Dev* 2014 Dec;79(4):25-50. doi: 10.1111/mono.12129.
4. Gupta P, Gupta N, Singh HP. Prevalence of Dental Caries in relation to Body Mass Index, Daily Sugar Intake, and Oral Hygiene Status in 12-Year-Old School Children in Mathura City: A Pilot Study. *Int J Pediatr* 2014;2014:921823. doi:10.1155/2014/921823.
5. Gläser-Ammann P, Lussi A, Bürgin W, Leisebach T. Dental knowledge and attitude toward school dental-health programs among parents of kindergarten children in Winterthur. *Swiss Dent J* 2014;124(7-8):770-83.
6. Moynihan P, Petersen PE. Diet, nutrition and the prevention of dental diseases. *Public Health Nutr* 2004 Feb;7(1A):201-26 DOI: 10.1079/PHN2003589.
7. Schroth RJ, Levi JA, Sellers EA, Friel J, Kliever E, Moffatt ME. Vitamin D status of children with severe early childhood caries: a case-control study. *BMC Pediatr* 2013 Oct 25;13:174. doi: 10.1186/1471-2431-13-174.
8. Wagner Y, Heinrich-Weltzien R. Pediatricians' oral health recommendations for 0- to 3-year-old children: results of a survey in Thuringia, Germany. *BMC Oral Health* 2014 May 1;14:44. doi: 10.1186/1472-6831-14-44.
9. Fleisch A F, Sheffield P E, Chinn C, Edelstein B L, Landrigan P J. Bisphenol A and related compounds in dental materials. *Paediatrics* 2010; 126: 760-768.
10. Van Landuyt K L, Nawrot T, Geebelen B et al. How much do resin-based dental materials release? A meta-analytical approach. *Dent Mater* 2011; 27: 723-747.
11. Olea N, Pulgar R, Pérez P, Olea-Serrano F, Rivas A, Novillo-Fertrell A, Pedraza V, Soto AM, Sonnenschein C. Estrogenicity of resin-based composites and sealants used in dentistry. *Environ Health Perspect* 1996 Mar;104(3):298-305.
12. Pulgar R, Olea-Serrano MF, Novillo-Fertrell A, Rivas A, Pazos P, Pedraza V, Navajas JM, Olea N. Determination of bisphenol A and related aromatic compounds released from bis-GMA-based composites and sealants by high performance liquid chromatography. *Environ Health Perspect* 2000 Jan;108(1):21-7.
13. Rivas A, Lacroix M, Olea-Serrano F, Laíos I, Leclercq G, Olea N. Estrogenic effect of a series of bisphenol analogues on gene and protein expression in MCF-7 breast cancer cells. *J Steroid Biochem Mol Biol* 2002 Sep;82(1):45-53. PubMed PMID: 12429138.
14. Lang IA, Galloway TS, Scarlett A, Henley WE, Depledge M, Wallace RB, Melzer D. Association of urinary bisphenol A concentration with medical disorders and laboratory abnormalities in adults. *JAMA* 2008 Sep 17;300(11):1303-10. doi: 10.1001/jama.300.11.1303.
15. EFSA Directiva 2011/8/UE de la Comisión de 28 de enero de 2011 que modifica la Directiva 2002/72/CE por lo que se refiere a la restricción del uso de bisfenol A en biberones de plástico para lactantes 29.1.2011 Diario Oficial de la Unión Europea.
16. EFSA, 2014 (<http://www.efsa.europa.eu/en/topics/topic/bisphenol.htm>).
17. Velasco J, Mariscal-Arcas M, Rivas A, Caballero ML, Hernández-Elizondo J, Olea-Serrano F. [Assessment of the diet of school children from Granada and influence of social factors]. *Nutr Hosp* 2009 Mar-Apr;24(2):193-9.
18. Mariscal-Arcas M, Velasco J, Monteagudo C, Caballero-Plasencia MA, Lorenzo-Tovar ML, Olea-Serrano F. Comparison of methods to evaluate the quality of the Mediterranean diet in a large representative sample of young people in Southern Spain. *Nutr Hosp* 2010 Nov-Dec;25(6):1006-13.
19. Mariscal-Arcas M, Romaguera D, Rivas A, Feriche B, Pons A, Tur JA, Olea-Serrano F. Diet quality of young people in southern Spain evaluated by a Mediterranean adaptation of the Diet Quality Index-International (DQI-I). *Br J Nutr* 2007 Dec;98(6):1267-73.
20. Mariscal-Arcas M, Rivas A, Velasco J, Ortega M, Caballero AM, Olea-Serrano F. Evaluation of the Mediterranean Diet Quality Index (KIDMED) in children and adolescents in Southern Spain. *Public Health Nutr* 2009 Sep;12(9):1408-12. doi: 10.1017/S1368980008004126.
21. DRI Dietary Guidelines, 2010. <http://www.cnpp.usda.gov/dietary-guidelines-2010>

22. Almerich-Silla JM, Boronat-Ferrer T, Montiel-Company JM, IranzoCortés JE Caries prevalence in children from Valencia (Spain) using ICDAS II criteria, 2010 *Med Oral Patol Oral Cir Bucal* 2014 Nov 1;19 (6):e574-80. doi:10.4317/medoral.19890).
23. Chi DL, Masterson EE, Carle AC, Mancl LA, Coldwell SE. Socioeconomic status, food security, and dental caries in US children: mediation analyses of data from the National Health and Nutrition Examination Survey, 2007-2008. *Am J Public Health* 2014 May;104(5):860-4. doi: 10.2105/AJPH.2013.301699.
24. Cortés-Martínicorena FJ, Doria-Bajo A, Asenjo-Madoz MA, Sainz de Murieta-Iriarte I, Ramón-Torrel JM, Cuenca-Sala E. Prevalencia de caries y estado periodontal de los niños y adolescentes de Navarra (2002) *RCOE*, 2003, Vol 8, N°4, 381-390.
25. Joskow R, Boyd Barr D, Barr JR, PhD; Calafat AM, Needham LL, Rubin C. Exposure to bisphenol A from bis-glycidyl dimethacrylate-based dental sealants, *JADA* 2006;137:353-62.
26. Rathee M, Malik P, Singh J. Bisphenol A in dental sealants and its estrogen like effect. *Indian journal of endocrinology and metabolism* 2012 , 16 (3): 339-342.
27. Kloukos D, Pandis, Eliades T. In vivo bisphenol-A release from dental pit and fissure sealants: A systematic review. *J of Dentistry* (2013) 41:659-667.
28. Muller-Bolla M, Lupi-Pegurier L, Bardakjian H, Velly AM. Effectiveness of school-based dental sealant programs among children from low-income backgrounds in France: a pragmatic randomized clinical trial. *Community Dent Oral Epidemiol* 2013; 41: 232-241.
29. Zimmerman-Downs JM, Shuman D, Stull SC, Ratzlaff RE Bisphenol A blood and saliva levels prior to and after dental sealant placement in adults. *J Dent Hyg* 2010 Summer;84(3):145-50.
30. Maserejian NN, Shrader P, Trachtenberg FL, Hauser R, Bellinger DC, Tavares M. Dental sealants and flowable composite restorations and psychosocial, neuropsychological, and physical development in children. *Pediatr Dent* 2014 Jan-Feb;36(1):68-75.
31. EFSA Journal Scientific Opinion on Dietary Reference Values for carbohydrates and dietary fibre 2010; 8(3):1462 [77 pp.]. doi:10.2903/j.efsa.2010.1462.
32. Dror DK, Allen LH. Dairy product intake in children and adolescents in developed countries: trends, nutritional contribution, and a review of association with health outcomes. *Nutr Rev* 2014 Feb;72(2):68-81. doi: 10.1111/nure.12078.