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Association between being overweight and oral health in Serbian schoolchildren

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Background. Childhood obesity, dental caries, and periodontal disease are major public health problems due to their adverse impact on the growth and development of children.

Aim. To examine the association between nutritional status, oral health, and lifestyle habits among schoolchildren in Serbia.

Design. This cross-sectional study assessed 422 children and adolescents aged 6–18 years with the following dental indexes analyzed: DMF/dmf (decayed, missed, and filled teeth), plaque index (PI), and gingival index (GI). Depending on their nutritional status, the subjects were categorized, as being 'normal weight,' 'at risk of overweight,' and 'overweight.' Logistic regression was applied to study the association between the dental indexes and independent variables: gender, age, toothbrushing, nutritional status, and lifestyle factors.

Results. Being overweight positively correlated with GI, but negatively correlated with the DMF/dmf index among the participants. Multivariate analysis showed a strong association between the weight category and toothbrushing with GI and PI. Overweight children (6–11 years) were less likely to have caries, whereas in older children/adolescents (12–18 years), caries was associated with the intake of sugar-sweetened juices.

Conclusions. Being overweight was found to be significantly associated with a higher probability of developing gingivitis and negatively associated with caries prevalence in Serbian children and adolescents.

Introduction

Childhood obesity is one of the major public health problems. Because of its global distribution and severe consequences, which include type 2 diabetes, osteoporosis, hypertension, and cardiovascular diseases, obesity is a serious health threat[1]. In 2006, the European Commission reported that 22 million children within the European Union are overweight or obese, with an increase in incidence of 400,000 new cases per year[2]. In the last decade, the prevalence of overweight and obesity in the Serbian population has also markedly increased. It has been estimated that around 19% of children are overweight[3]. Lifestyle factors, such as lack of physical activity, changes in eating habits, and social changes, have been considered as crucial factors for the global spread of obesity[4]. Furthermore, dental caries and periodontal disease have traditionally been considered one of the greatest public health burdens because of their adverse impact on the growth and development of children[5,6].

Oral health and obesity share common risk factors, as both are associated with unhealthy dietary habits – sugary soft drinks, snacks, and sugar-rich diets[7]. Therefore, the World Health Organization (WHO) emphasizes the need to adopt a unified approach for the -promotion of general and oral health instead of the previous single-level strategies[6]. The 'common risk factor' approach has been proposed as more rational, cost-effective, sustainable, and affordable[6,8].

The period from childhood to adolescence is a critical stage of life during which children

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acquire important behavioral habits relevant to their general and oral health[9]. Unhealthy dietary habits established in childhood tend to be carried throughout adulthood. It is postulated that the low socioeconomic status (SES) groups are particularly vulnerable to developing such habits, due to inadequate knowledge and the inability to afford healthy food[10]; however, there is a lack of research addressing the relationship between dental health, periodontal disease, obesity, and lifestyle habits in Central and Eastern Europe, which have recently passed through a socioeconomic and nutritional transition. Thus, the aim of this study was to examine possible relationships between bodyweight, oral health, and lifestyle habits among children and adolescents in Serbia.

Material and methods

Study design and subjects

This cross-sectional study included 422 children and adolescents (187 males and 235 females) aged 6–18 years (12.04 ± 3.15), who attended a systematic dental examination between January 2012 and January 2014. To obtain a sufficient number of overweight/obese participants for the study, 278 of the subjects were recruited at the Nutritional counseling at the Institute for Mother and Child Health Care in Belgrade, Serbia. The remaining 144 children and adolescents were recruited at the primary health center in Subotica, Serbia. None of the subjects had received periodontal treatment within the previous 6 months. The study protocol was approved by the Ethical Committee of the Faculty of Dentistry, University of Belgrade. Parents were informed about the purpose of the study and signed an informed consent form. They were also asked to complete a questionnaire on general information, diet, oral hygiene, and living habits of their children. Sixteen children/adolescents were excluded due to presence of autoimmune disease ($n = 1$), lack of the signed informed consent by parents ($n = 3$), or being underweight ($n = 12$). A total of 406 children and adolescents were enrolled in the study. Examination of the oral health status of participants was carried out by two dentists through a standard dental examination using a dental probe and mirror. Dental caries was determined by DMF/dmf index [decayed, missed, filled teeth for permanent (DMF) and primary dentition (dmf)]. For the statistical analysis DMF/dmf index was coded as 0 (no decayed, missed, or filled teeth) or 1 (one or more dmf teeth). The oral hygiene was assessed using the Simplified Debris (Plaque) Index Greene-Vermilion[11] (PI). The gingival health was assessed using the gingival index (GI), as described by Löe and Silness[12]. Clinical measurements were in accordance with the WHO criteria[13].

Anthropometric measurements

A qualified nutritionist conducted anthropometric measurements: The height and weight of the participants dressed in light clothing without shoes were determined. The subjects were weighed with a lever-actuated balance to the nearest 0.1 kg (TBF-300, Tanita Corp., Tokyo, Japan). Standing height was measured using a wall-mounted stadiometer (Leicester Height Meter, Child Growth Foundation, London, UK, range 60–207 cm). Body mass index (BMI) was calculated as the bodyweight (in kg) divided by the square of the height (in m). Percentiles defined the position of a particular index value compared to children and adolescents of the same sex and age. According to the WHO growth references for children and adolescents, BMI between the 5th and 85th percentile is categorized as 'normal weight,' children and adolescents with a BMI between the 85th and 95th percentile are classed as 'at risk of overweight,' and those with BMI greater than the 95th percentile as 'overweight.'[14–16]

Lifestyle factors

The questionnaire on lifestyle contained 35 questions, with categorized answers, on participants' daily habits. These included as follows: daily consumption of sugary foods (cookies, sweets, chocolate): yes or no; daily consumption of sugar-sweetened soft drinks

divided into juice and soda (fizzy drinks): yes or no; physical activity: >1 h/day or <1 h/day; watching television or using a computer: >2 h/day or <2 h/day; socioeconomic status classification: low, moderate, or high, according to the household income, with nationally defined cutoffs (according to Eurostat[17]). The frequency of toothbrushing was based on the six-point Likert scale and divided into the following: never, less than once a week, once a week, more than once a week, once daily, twice daily, or more. For the statistical analysis, this was coded as 1 (twice daily or more) or 0 (less than twice daily).

Statistical methods

Data were analyzed by the SPSS 11.5 statistical package software for the Social Sciences (SPSS Inc., Chicago, IL, USA). The Kolmogorov–Smirnov test was used for assessing the distribution of all parameters. As all variables showed non-normal distribution, Kruskal–Wallis test and Mann–Whitney *U*-test were applied. Chi-square tests by cross-tabulation were applied to compare frequencies. Spearman's correlation coefficient was used to determine the correlation of DMF/dmf score, GI, and PI with the nutritional status, using BMI percentile as continuous variable. Associations between dental indexes and gender, age, sweet consumption, sugar-sweetened juices and soda drinks consumption, snacks, toothbrushing, nutritional status, physical activity, and TV watching were tested using univariate and multivariate logistic regression analysis and expressed as odds ratios (OR) with 95% confidence intervals (CI). Cutoffs for PI and GI were set as 0.6 and 1.0, respectively[11,12]. The Hosmer and Lemeshow test was used to identify differences in proportions of dichotomous variables (used to indicate presence/absence of a certain case). The level of significance was set at 0.05.

Results

The demographic data, dietary habits, physical activity, and socioeconomic status of the study participants, grouped according to their nutritional status, are shown in Table 1. Approximately 32.5% of the children and adolescents included in this study were of normal weight, 33% were classed as 'at risk of overweight,' and 34.5% were considered overweight. Daily consumption of sweets was significantly higher than occasional/never consumption in all of the groups; however, the majority of the children and adolescents studied here consumed snacks and sodas occasionally. Furthermore, the data on physical activity were of concern: Only 33% of the overweight and 43% of the at-risk overweight participants were physically active for more than 1 h/day compared to 71% of the children and adolescents of normal weight. In line with physical activity, the overweight study participants spent more time in front of a computer or the TV. Data on toothbrushing showed that only 53% of overweight children and adolescents brushed their teeth twice per day or more. Interestingly, the proportion of children and adolescents with a high SES was significantly greater than those with a low SES in both the 'at risk of overweight' and 'overweight' groups (Table 1).

The data on oral health in relation to nutritional status are presented in Table 2. In spite of poor oral hygiene, overweight children and adolescents were found to have significantly more healthy primary and permanent teeth (group 12–18 years) than those of normal weight, but also a significantly higher GI ($P < 0.001$). Children and adolescents of normal weight had a significantly higher average number of decayed, filled permanent teeth and missed primary teeth ($P < 0.01$), as well as a higher DMF/dmf index ($P < 0.001$) compared to the 'at risk of overweight' and 'overweight' participants.

Spearman's correlation between the nutritional status and dental health indexes in the children and adolescents studied is shown in Table 3. A positive correlation was found between BMI and GI ($r = 0.348$, $P < 0.001$), although there was no correlation between PI and nutritional status. Number of healthy primary teeth and number of healthy permanent teeth in the 12- to 18-year-old group also correlated positively with the nutritional status. Number of filled teeth (except primary

Table 1. Demographic characteristic, dietary habits, physical activity, and socioeconomic status according to nutritional status.

	Normal weight (*N* = 132)	At risk of overweight (*N* = 134)	Overweight (*N* = 140)	*P**
Gender				
Boys	50 (38%)	62 (46%)	66 (47%)	0.241
Girls	82 (62%)	72 (54%)	74 (53%)	
Age				
6–11	68 (52%)	46 (34%)	92 (66%)	0.001
12–18	64 (48%)	88 (66%)	48 (34%)	
Sweet consumption				
Everyday	80 (61%)	100 (75%)	108 (77%)	0.006
Occasionally/never	52 (39%)	34 (25%)	32 (23%)	
Sugar-sweetened juices				
Everyday	54 (41%)	50 (37%)	50 (36%)	0.667
Occasionally/never	78 (59%)	84 (63%)	90 (64%)	
Sugar-sweetened sodas				
Everyday	12 (9%)	38 (28%)	38 (27%)	<0.001
Occasionally/never	120 (91%)	96 (72%)	102 (73%)	
Snacks				
Everyday	38 (29%)	48 (36%)	80 (57%)	<0.001
Occasionally/never	94 (71%)	86 (64%)	60 (43%)	
Daily brushing				
2×/day	98 (74%)	96 (72%)	74 (53%)	<0.001
<2×/day	34 (26%)	38 (28%)	66 (47%)	
Daily physical activity				
More than 1 h	94 (71%)	58 (43%)	46 (33%)	<0.001
<1 h	38 (29%)	76 (57%)	94 (67%)	
Daily TV/computer				
<2 h	96 (73%)	82 (61%)	48 (34%)	<0.001
More than 2 h	36 (27%)	52 (39%)	92 (66%)	
Socioeconomic status				
Low	60 (47%)	28 (23%)	24 (19%)	<0.001
Medium/high	68 (53%)	94 (77%)	104 (81%)	

*Chi-square test is used to compare frequencies.

teeth), decayed teeth, missed primary teeth, and DMF/dmf index all correlated negatively with the weight status.

Univariate logistic regression revealed that only 2 variables (toothbrushing and being at risk of overweight) of 10 examined variables yielded a statistically significant unique contribution to the PI (Table 4). Thus, the subjects practicing regular toothbrushing were 50% less likely to have elevated PI than those who brushed their teeth irregularly (OR 0.5, 95% CI 0.3–0.8). The risk of an increased PI in the 'at risk of overweight' group was 2.6 (95% CI 1.3–4.4), that is, these subjects were more than twice as likely to have increased PI than the normal weight group. After adjusting for all confounding variables, multivariate regression showed that both toothbrushing and being 'at risk of overweight' remained associated with the PI (OR 0.5, 95% CI 0.2–0.9 and OR 2.5, 95% CI 1.2–4.7, respectively).

The probability of increased GI was associated with sugar-sweetened sodas, lack of toothbrushing, being at risk of overweight, and being overweight in the univariate analysis (Table 4). Regular toothbrushing reduced the risk of an increased GI around three times (OR 0.3, 95% CI 0.2–0.5). Likewise, the overweight and 'at risk of overweight' children and adolescents were more likely to have a higher GI. The weight category was the strongest predictor of having an increased GI, with OR 5.1 (95% CI 2.2–11.5) for the 'at risk of overweight,' and OR 3.9 (95% CI 1.7–8.8) for the overweight group. Children and adolescents who often consumed sugar-sweetened sodas were twice more likely to have an increased GI than those who consumed sodas occasionally or never (OR 2.0,

Table 2. Oral health status and dental indexes according to the nutritional status.

	Normal weight (*n* = 132)	At risk of overweight (*n* = 134)	Overweight (*n* = 140)	*P*#
Number of healthy teeth	(a) 5 (5)	(a) 4 (13)	(a) 7 (20)**††	0.001
	(b) 12 (6.5)	(b) 13.5 (18.5)	(b) 12 (8)	0.304
	(c) 19 (4)	(c) 23 (7)***	(c) 24 (6)***	<0.001
Number of decayed teeth	(a) 3 (4.25)	(a) 2 (1)*	(a) 1 (3)*	0.001
	(b) 1 (2)	(b) 1 (2)	(b) 0 (1)**††	0.004
	(c) 4 (4.25)	(c) 2 (4)**	(c) 1 (5)**	<0.001
Number of missed teeth	(a) 0 (2)	(a) 0 (2)**	(a) 0 (3)**	<0.001
	(b) 0 (0)	(b) 0 (0)	(b) 0 (0)	1.000
	(c) 0 (0)	(c) 0 (0)	(c) 0 (0)	1.000
Number of filled teeth	(a) 0 (2)	(a) 0 (0)	(a) 0 (0)	0.683
	(b) 1 (2)	(b) 0 (2)	(b) 0 (0)**††	<0.001
	(c) 3 (4)	(c) 1 (3)***	(c) 1 (2)***	<0.001
DMF/dmf index	(a) 4 (5)	(a) 2 (3)**	(a) 1 (3)**	<0.001
	(b) 2 (3.25)	(b) 2 (3.5)	(b) 0 (2.5)*†	<0.001
	(c) 7 (4.25)	(c) 5 (7)***	(c) 3 (5)***	<0.001
PI	0.58 (0.37)	0.54 (0.69)	0.71 (0.66)	0.300
GI	0.29 (0.32)	0.54 (0.77) ***	0.58 (0.71)***	<0.001
Number of caries free children and adolescents	26 (19.7%)	30 (22.4%)	39 (29.7%)	

(a) Primary teeth in children/adolescents 6–11 years. (b) Permanent teeth in children/adolescents 6–11 years. (c) Permanent teeth in children/adolescents 12–18 years.
PI, plaque index; GI, gingival index; DMF, decayed, missed, filled teeth index for permanent dentition; dmf, decayed, missed, filled teeth index for primary dentition.
Results are expressed as median (interquartile range).
#Kruskal–Wallis test was applied to test the differences between the three groups.
*$P < 0.05$, **$P < 0.01$, and ***$P < 0.001$ when compared with normal weight group; †$P < 0.05$ and ††$P < 0.01$ when compared with at risk of overweight group, according to Mann–Whitney *U*-test.

Table 3. Spearman's correlation between the nutritional status and plaque index (PI), gingival index (GI) and DMF/dmf index.

	r	*P*
Healthy teeth	(a) 0.251	0.001
	(b) 0.063	0.416
	(c) 0.358	<0.001
Decayed teeth	(a) −0.275	0.001
	(b) −0.250	0.001
	(c) −0.178	0.006
Missed teeth	(a) −0.414	<0.001
	(b)/	/
	(c) 0.013	0.838
Filled teeth	(a) −0.032	0.678
	(b) −0.350	<0.001
	(c) −0.362	<0.001
DMF/dmf	(a) −0.318	0.001
	(b) −0.348	<0.001
	(c) −0.375	<0.001
Total PI	0.060	0.231
Total GI	0.348	<0.001

(a) Primary teeth in children/adolescents 6–11 years. (b) Permanent teeth in children/adolescents 6–11 years. (c) Permanent teeth in children/adolescents 12–18 years.
r – Spearman's rho.

95% CI 1.1–3.4). Adjusted for the effects of confounders, the OR for being overweight was even higher (9.1, 95% CI 2.7–31.1), whereas consuming soda drinks showed no association with the GI.

In the group of children aged 6–11 years, the gender and being overweight showed significant association with both dmf and DMF, whereas age and lack of toothbrushing also contributed to the DMF (Table 4); however, multiple regression found that only age (OR 1.6, 95% CI 1.1–2.2) and excess weight (OR 0.2, 95% CI 0.1–0.8) remained associated with the DMF after adjusting for the confounder effects; however, the association between a higher dmf index and gender remained unchanged (0.3, 95% CI 0.1–0.6), showing that girls were significantly less likely to have dental caries on primary teeth than boys, independently of the examined confounders. Dental caries among both the children and the adolescents was strongly positively associated with the consumption of sugar-sweetened juices (OR 4.4, 95% CI 1.4–13.1), although a negative association was found with the consumption of fizzy drinks (OR 0.4, 95% CI 0.2–1.0); however, after the adjustment, the association was confirmed

Table 4. Univariate and multivariate analysis of the associations between the dental indexes and age, gender, nutritional status, and lifestyle factors.

	Univariate analysis		Multivariate analysis	
	Unadjusted OR (95% CI)	*P*-value	Adjusted OR* (95% CI)	*P*-value
PI				
Toothbrushing	0.5 (0.3–0.8)	0.008	0.5 (0.2–0.9)	0.029
At risk of overweight	2.6 (1.3–4.4)	0.005	2.5 (1.2–4.7)	0.010
GI				
Sugar-sweetened sodas	2.0 (1.1–3.4)	0.026	1.2 (0.5–2.9)	0.765
Toothbrushing	0.3 (0.2–0.5)	<0.001	0.3 (0.2–0.8)	0.008
At risk of overweight	5.1 (2.2–11.5)	<0.001	5.3 (2.2–13.1)	<0.001
Overweight	3.9 (1.7–8.8)	0.001	9.1 (2.7–31.1)	<0.001
dmf				
Gender	0.3 (0.1–0.6)	0.001	0.3 (0.1–0.6)	0.001
Overweight	0.4 (0.2–0.9)	0.027	0.3 (0.1–1.1)	0.080
DMF 6–11 years				
Gender†	0.5 (0.3–0.9)	0.031	0.7 (0.3–1.7)	0.371
Age‡	1.8 (1.4–2.3)	<0.001	1.6 (1.1–2.2)	0.009
Toothbrushing	2.0 (1.1–3.9)	0.030	1.5 (0.6–4.1)	0.390
Overweight	0.3 (0.1–0.5)	<0.001	0.2 (0.1–0.8)	0.023
DMF 12–18 years				
Sugar-sweetened juices	4.4 (1.4–13.1)	0.008	14.4 (1.7–124.7)	0.016
Sugar-sweetened sodas	0.4 (0.2–1.0)	0.038	0.1 (0.0–1.1)	0.065

*Adjusted for age, gender, sweet consumption, sugar-sweetened juices and sodas, snacks, toothbrushing, nutritional status, physical activity, and TV watching.
†The gender was coded 1 for boys and 2 for girls.
‡Age was entered as continuous variable.

only for the sweetened juices, with an even higher OR (14.4, 95% CI 1.7–124.7).

Discussion

We believe this to be the first study to provide data on the relationship between the nutritional status, oral health, and lifestyle habits among schoolchildren in Serbia. Our results demonstrate a positive association between the BMI and the gingival and plaque indexes. The data also show that schoolchildren who were overweight had a lower risk of developing dental caries.

Childhood obesity is a major problem worldwide, underlining the risk of developing metabolic complications, diabetes, and cardiovascular disease in adolescence and early adulthood. Although obesity and oral health are globally leading health problems in children and adolescents, the research into the relationship between obesity and the periodontal status or frequency of caries in children has been neglected; however, obesity and oral diseases share many risk factors, including the lifestyle. The main findings of this study demonstrate a positive association between being overweight and periodontal risk indicators in children and adolescents, which in the long term may lead to chronic systemic inflammation. Our results are in line with other recently reported data[18,19]. Furthermore, we have found the highest frequency of sweets and snacks consumption, sugar-sweetened soft drinks, time spent in front of the TV or a computer, as well as the lowest physical activity and oral hygiene habits in the overweight children and adolescents. Besides leading to being overweight, such dietary habits and lifestyle also trigger the immune system by generating a state of chronic systemic inflammation[20]. In this respect, periodontal tissue and blood vessels may be affected indirectly by an imbalance in the host's immunity or directly by poor diet and oral hygiene leading to periodontal disease. These potential mechanisms have already been implicated in the positive associ-

ation between being overweight and gingival bleeding among young adults. Therefore, gingival bleeding as an indicator of periodontal disease, especially among children, could suggest that overweight children and adolescents have an increased risk of chronic systemic inflammation, which is involved in the development of chronic non-communicable diseases[21]. Regarding the association between periodontal disease and physical activity, Al Zahrani *et al.*[22] previously reported that individuals who demonstrated a health-enhancing behavior (maintaining a normal weight, healthy diet, and physical activity) were 40% less likely to have periodontitis compared to those who exhibited none of these.

On the other hand, our study shows that children and adolescents who were classed as overweight or 'at risk of overweight' had a lower dental caries indexes compared with the normal weight group, despite having higher sweets consumption. The differences were found for both primary and permanent teeth and in all age-groups. A negative correlation between bodyweight and dental caries was found in a study by Sohn[23]; however, some authors have reported that children classed as 'at risk of overweight' have a higher risk of dental caries compared with normal weight or overweight children[24]. Others found no significant differences in the prevalence of caries among different BMI groups[25], whereas in contrast to our study, Willerhausen *et al.*[26] demonstrated a significant positive association between the frequency of caries and the body weight. After adjustment for age, gender, toothbrushing, consumption of sweets, snacks, and sugar-sweetened soft drinks, we found a positive association between being overweight and DMF only for permanent teeth in the 6- to 11-year age-group. Considering all these conflicting findings, we conclude that there is no convincing evidence that overweight children and adolescents are at an increased risk of developing dental caries. Nevertheless, other dental diseases besides caries are undoubtedly related to being overweight and it would be important to include weight and height measurements in the current and future oral health preventive programs.

Consumption of sweets and sugar-sweet ened fizzy drinks, which were higher in the 'at risk of overweight' and the overweight participants, was not associated with caries in our study, whereas consumption of sugar-sweetened juices was associated with an increased presence of dental caries in 12- to 18-year-old adolescents. In support of this finding, a meta-analysis by Burt and Pai[27] has shown that the relationship between sugar consumption and caries is much weaker in the modern age of fluoride exposure. In addition, studies have shown that frequency of sweet consumption is more important for the development of caries than the amount of sweets[28]. These reports support our findings that overweight children/adolescents had fewer decayed teeth, despite a higher sweet consumption than the children/adolescents of normal weight.

One limitation of this study is that pubertal stages of children and adolescents were not evaluated as there is evidence that childhood obesity can induce early puberty[29]. Due to physiological changes in puberty, there is an increase in gingivitis levels, which might reflect poor hygiene habits, plaque accumulation, and an inflammatory response related to tooth eruption and exfoliation but could also result from hormonal changes. The PI and GI indexes need to be evaluated in the future oral health studies in children and adolescents. A potential lack of objectivity of the parents about the lifestyle habits of their children could be another limitation[30]. In addition, a potential selection bias in the participant recruitment at the two study sites was also possible, although our statistical analysis showed no significant differences in the variables of interest, apart from the nutritional status.

In summary, this study of children and adolescents in Serbia shows a significant positive correlation between the gingival index and being overweight, but a negative association between caries prevalence and the BMI. As our results indicate that being at risk of overweight or overweight is a potential risk factor for developing periodontal disease, promotion of healthy nutrition and physical activity in children and

adolescents are necessary to prevent oral pathology, which can further affect the general health and well-being.

Why this paper is important to paediatric dentists

- Recognition that the oral and general health are interlinked is essential for pediatric dentists to determine proper oral healthcare programs and strategies at both the individual and community care level.
- Appropriate interventions to improve oral health may also reduce the risk factors for childhood obesity, which is known to present a serious threat to general health. Thus, pediatric dentists might be able to identify children/adolescents that have a high risk of developing chronic disease.
- Our findings support the WHO initiative for the adoption of a collaborative 'Common risk factor approach,' a unified approach for the promotion of general and oral health, as more resource-efficient, rational, cost-effective, sustainable, and affordable than a targeted, disease-specific approach.

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Conflict of interest

The authors declare no conflict of interest.

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