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The relationship between body mass index and oral health indices in adolescent children: a cross-sectional study.

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Abstract:

Background and Objective: The prevalence of obesity has increased dramatically worldwide in recent years, becoming a growing public health concern globally, especially among children, due to its association with systemic health. Despite emerging evidence suggesting a bidirectional relationship between obesity and oral health, limited studies have examined this association in adolescent populations, particularly in Syria. This study aimed to investigate the relationship between body mass index (BMI) and oral h
ealth indices, including gingival index (GI), plaque index (PI), and decayed, missing, and filled teeth (DMFT) index, among adolescents aged 12-14 years in Damascus, Syria.

Materials and Methods: In this cross-sectional study, 654 children were classified according to their BMI for age and sex into the following groups; underweight, normal weight, overweight, and obese based on the Centers for Disease Control and Prevention (CDC) criteria. Data on plaque index (PI), gingival index (GI), and caries index of decayed, missing, and filled teeth (DMFT) were collected. Data were analyzed by SPSS 26 using descriptive tests, the Kruskal-Wallis test, and the Spearman correlation test at the 0.05 level.

Results: The mean values of oral health indices (GI, PI, and DMFT) were significantly higher in obese individuals than in individuals with low or normal weight ($P<0.05$). Spearman correlation coefficient showed a significant positive relationship of weak intensity between gingival and plaque indices and BMI ($P<0.05$) and moderate intensity between caries index and BMI ($P>0.01$).

Conclusions: Based on the current study, we note the association of oral health with BMI in children in Damascus, where high values of gingival, plaque, and caries indices were associated with high BMI. Hence, more studies are needed to confirm these findings.

Keywords: Oral health, Body Mass Index, Gingivitis, Dental caries, Obesity.

العلاقة بين مشعر كتلة الجسم ومشعرات الصحة الفموية عند الأطفال المراهقين: دراسة مقطعية.

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الملخص:

خلفية البحث والهدف منه: :لقد تزايد انتشار السمنة بشكل كبير في جميع أنحاء العالم في السنوات الأخيرة، وأصبحت مصدر قلق متزايد للصحة العامة عالمياً، وخاصة بين الأطفال، بسبب ارتباطها بالصحة الجهازية. وعلى الرغم من الأدلة الناشئة التي تشير إلى وجود علاقة ثنائية الاتجاه بين السمنة والصحة الفموية، فقد بحثت دراسات محدودة هذا الارتباط عند المراهقين، وخاصة في سوريا. تهدف هذه الدراسة إلى البحث في العلاقة بين مؤشر كتلة الجسم (BMI) ومؤشرات الصحة الفموية، بما في ذلك مؤشر اللثة (GI)، مؤشر اللويحة (PI)، ومؤشر الأسنان المنخورة والمفقودة والمرممة (DMFT)، بين المراهقين الذين تتراوح أعمارهم بين 12 و 14 عامًا في دمشق، سوريا.

المواد والطرائق: في هذه الدراسة المقطعية، تم وضع 654 طفلاً وطفلةً وفقًا لمشعر كتلة الجسم بالنسبة إلى العمر والجنس في المجموعات التالية؛ نقص الوزن، الوزن الطبيعي، زيادة الوزن والسمنة وذلك اعتماداً على معايير مراكز السيطرة على الأمراض والوقاية منها CDC. تم جمع البيانات المتعلقة بمشعر اللويحة (PI)، مشعر اللثة (GI)، ومشعر الأسنان المنخورة والمفقودة والمرممة (DMFT). تم تحليل البيانات بواسطة برنامج SPSS 26 باستخدام الاختبارات الوصفية واختبار كروسكال واليز Kruskal-Wallis واختبار الارتباط سبيرمان spearman وذلك عند مستوى 0.05.

النتائج: كانت قيمة متوسطات مشعرات الصحة الفموية (مشعر اللثة – مشعر اللويحة – ذوي الوزن المنخفض أو الطبيعي ($P<0.05$). أظهر معامل ارتباط سبيرمان علاقة إيجابية مهمة ضعيفة الشدة بين مشعرات اللثة واللويحة ومشعر كتلة الجسم ($P<0.05$) ومتوسطة الشدة بين مشعر النخور ومشعر كتلة الجسم ($P<.001$).

الاستنتاجات: بناءً على الدراسة الحالية، نلاحظ ارتباط الصحة الفموية مع مشعر كتلة الجسم عند الأطفال في دمشق، حيث ترافقت القيم الكبيرة لمشعرات اللثة واللويحة والنخور مع ارتفاع مشعر كتلة الجسم

الكلمات المفتاحية: الصحة الفموية، مشعر كتلة الجسم، التهاب اللثة، نخور الأسنان، السمنة

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Introduction:

Obesity is a global problem that has become increasingly prevalent in recent years, especially among children (1),(2). Obesity occurs due to an imbalance between the body's energy intake and consumption, leading to significant fat accumulation, obesity, and increased total body mass (3). It is one of the most common problems that can affect public health, as it is an important factor that can lead to cardiovascular diseases, diabetes, and cancer (4). Childhood obesity can also lead to immediate and long-term health risks, such as high blood pressure, type 2 diabetes, metabolic syndrome, and behavioral and mental problems (2). There are many different methods and measures to assess obesity. However, none of them are completely ideal. The Body Mass Index (BMI) is the most applicable due to its feasibility and high accuracy (4),(5).

Periodontal disease, tooth decay, and tooth loss are the most common diseases reflecting poor oral health (6), which can influence the development of diseases such as cancer, cardiovascular diseases, and others (7). One possible mechanism is that oral diseases not only cause local inflammatory effects affecting the oral components but also cause systemic inflammation (6). Increased inflammatory reactions in the body may be one of the basic mechanisms of obesity (8). The systemic distribution of inflammation resulting from tooth decay and periodontal pockets causes increased secretion of inflammatory cytokines, which play an important role in the development of obesity (9).

The different composition of oral microorganisms, which plays a significant role in the development of various diseases (10), tends to be more diverse and variable in individuals who are obese or overweight (3),(11). Consequently, maintaining proper oral care habits that lower oral microbiota levels and enhance oral health may contribute to preventing both systemic diseases and obesity (7). According to Saito et al (12), a higher BMI is associated with an elevated risk of periodontitis. Similarly, Chang et al (1), observed that while tooth decay and tooth loss are linked to higher BMI, individuals with lower BMI exhibit a greater frequency of toothbrushing.

On the other hand, dental caries and tooth loss can adversely impact food consumption and nutritional status, potentially leading to malnutrition or obesity (13). Since the development of both dental caries and obesity have a background of common risk factors such as lifestyle, dietary habits, genetic predisposition, socioeconomic status, and other environmental factors, some studies suggest that overweight and obesity may serve as indicators for dental caries (2),(14). This study hypothesized that poor oral health could play a role in the onset and progression of obesity, while obesity, in turn, may exacerbate oral health issues. Poor oral health can be indicated by the presence of gingivitis, tooth decay, tooth loss, and plaque accumulation. However, research exploring the association between oral health indicators and obesity remains limited, particularly among children in Damascus, Syria. Therefore, this study aimed to investigate the relationship between
oral health indicators and BMI.

Materials and methods:

Study design and setting:

A cross-sectional study was conducted to evaluate the relationship between obesity and oral health indices, involving 654 children from Damascus, Syria, between March 2023 and April 2024. All procedures complied with relevant ethical guidelines and were approved by the Ethical Research Committee of Damascus University (Approval No. 2601). Prior to data collection, informed consent was obtained from the parents of all participants. The study adhered to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for reporting epidemiological descriptive studies.

Study sample:

The sample size for this study was calculated using the formula $N = \frac{z^2 p(1-p)}{d^2}$, which is commonly recommended for cross-sectional descriptive studies. A standard normal variable (z) of 1.96 was used corresponding to a type I error of 5%. The population proportion (p) was assumed to be 50%, and the margin of error (d) was set at 5%. Based on these parameters, the minimum required sample size was calculated to be 385 participants. However, to enhance the study's robustness, 654 children were ultimately included.

Participants were recruited after obtaining signed informed consent from their parents. Only boys and girls of Syrian descent between the ages of 12 and 14 met the inclusion criteria. Children with particular needs, medical illnesses or chronic diseases, medication use, orthodontic appliance use, smoking, and difficult behavior were all excluded.

Assessment of BMI:

BMI was calculated for each individual to evaluate obesity status. BMI is defined as the ratio of weight (kg) to height squared (m^2). Heights were measured using a graduated ruler positioned at the top of the child's head, while weights were recorded using a digital scale placed on a firm, stable surface. Weights were rounded to the nearest 100 g, and heights to the nearest 0.1 mm. To ensure accuracy,

participants were instructed to remove heavy clothing and shoes, and proper standing posture was maintained by ensuring they stood at the center of the scale.

Age- and sex-adjusted obesity scores were determined using the Centers for Disease Control and Prevention (CDC) criteria (15). The BMI categories for children and adolescents are based on BMI percentiles adjusted for sex and age, which account for ongoing growth. Importantly, race was not included as a variable in the calculation of BMI percentiles. Obesity classifications for children and adolescents aged 2–19 years were as follows: underweight (BMI < 5^{th} percentile), healthy weight (BMI 5^{th}–85^{th} percentile), overweight (BMI 85^{th}–95^{th} percentile), and obese (BMI ≥ 95^{th} percentile).

Assessment of oral health indicators:

A comprehensive dental examination was conducted for all study participants by the researcher only to reduce inter-examiner variability, with assistance from another dentist for precise data recording. Each child was seated in a chair positioned opposite and slightly to the left of the researcher, ensuring a clear view under a consistent light source. The examination proceeded in a sequential clockwise direction, beginning with the last tooth in the upper right quadrant and concluding with the last tooth in the lower right quadrant. Clinical examination tools were used for the assessments, including a mirror, dental probe, forceps, and a WHO periodontal probe. To ensure consistency and reliability, approximately 20% of the children were re-examined randomly to evaluate inter-examiner reliability.

The DMFT index (Decayed, Missing, and Filled Teeth) was calculated following WHO guidelines. This index represents the sum of decayed, missing, and filled teeth in the permanent dentition. The D (Decayed) component includes teeth with caries, recurrent caries in restored teeth, and temporary fillings. The M (Missing) component represents teeth lost due to untreated caries, while the F (Filled) component includes teeth restored without evidence of caries (16).

To evaluate the gingival health status, the Gingival Index (GI) by Löe and Silness (17) was employed, using the following scoring criteria:

Grade 0: Normal gingiva.

Grade 1: Mild inflammation characterized by slight discoloration and edema, without bleeding on probing.

Grade 2: Moderate inflammation, including redness, edema, and bleeding on probing.

Grade 3: Severe inflammation, marked by pronounced redness and spontaneous bleeding.

The index was then calculated by dividing the total score by the number of teeth examined. The resulting values were classified as follows: (0.1 – 1) Mild inflammation, (1.1 – 2) Moderate inflammation, and (2.1 – 3) Severe inflammation.

The Plaque Index (PI) was also assessed to determine the participants' level of oral care, using the methodology by Greene and Vermilion (18). All teeth present were evaluated, excluding loose or erupting teeth. A periodontal probe was used to examine plaque in the gingival sulcus on the buccal surface of each tooth. Each tooth was scored as follows:

Grade 0: No plaque.

Grade 1: Plaque covering less than one-third of the tooth surface.

Grade 2: Plaque covering between one-third and two-thirds of the tooth surface.

Grade 3: Plaque covering more than two-thirds of the tooth surface.

The PI was calculated by dividing the total score by the number of teeth examined. The results were categorized as follows: (0.1 - 1) Mild (good oral care), (1.1 - 2) Moderate (average oral care), and (2.1 - 3) Severe (poor oral care).

Statistical analysis:

The data were analyzed using SPSS 26.0 software (IBM, Chicago, USA). Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize the characteristics of the study participants. The Kolmogorov-Smirnov test was applied to evaluate the normality of the data distribution, with a statistical significance level set at 0.05. For the comparison of continuous variables, the Kruskal-Wallis test was utilized. Additionally, the Spearman correlation coefficient was calculated to examine potential relationships between BMI and various oral health indicators.

Results:

This study involved a total of 654 children aged 12–14 years, with females constituting the majority of the sample (53%). The distribution of participants across age groups was relatively balanced: 34.3% were 12 years old, 32.9% were 13 years old, and 32.8% were 14 years old. Among the participants, 19.8% were classified as overweight, and 9.9% as obese. In terms of oral health parameters, 89% of the children had dental caries (DMFT > 0), 88.7% exhibited gingivitis to varying degrees (GI > 0), and 93% had plaque accumulation in varying severities (PI > 0) (Table 1).

Children aged 14 years demonstrated the highest prevalence of overweight status (32.1%), gingivitis

(89.8%), plaque accumulation (95.3%), and dental caries (90.2%) within the sample. Females had a higher proportion of normal weight (67.2%) and overweight (21.4%) classifications compared to males and also exhibited higher rates of gingivitis (89.6%) and dental caries (89.3%). Conversely, males showed a greater prevalence of plaque accumulation (93.6%) (Table 2).

Table(1): Descriptive statistics for research variables

Variables	Groups	Number	Percentage %
Age	12	225	34.3%
	13	216	32.9%
	14	215	32.8%
Gender	Male	311	47.4%
	Female	345	52.6%
BMI	Underweight	31	4.7%
	Normal weight	430	65.5%
	Overweight	130	19.8%
	Obese	65	9.9%
GI	No gingivitis	74	11.3%
	Mild	335	51.1%
	Moderate	200	30.5%
	High	47	7.2%
PI	No plaque	46	7%
	Mild	268	40.9%
	Moderate	233	35.5%
	High	109	16.6%
DMFT	No caries	72	11%
	With caries	584	89%

Table(2): Descriptive statistics of research variables according to gender and age

Variables	Groups	Gender		Age		
		Male	Female	12	13	14
BMI	Underweight	15 (4.8%)	16 (4.6%)	14 (6.2%)	10 (4.6%)	7 (3.2%)
	Normal weight	198 (63.7%)	232 (67.2%)	175 (77.8%)	139 (64.4%)	116 (54%)
	Overweight	56 (18%)	74 (21.4%)	21 (9.3%)	40 (18.5%)	69 (32.1%)
	Obese	42 (13.5%)	23 (6.7%)	15(6.7%)	27 (12.5%)	23 (10.7%)
GI	No gingivitis	38 (12.2%)	36 (10.4%)	29 (12.9%)	23 (10.6%)	22 (10.2%)
	Mild	142 (45.7%)	193 (55.9%)	117 (52%)	96 (44.4%)	122 (56.7%)
	Moderate	109 (35%)	91 (26.4%)	70 (31.1%)	74 (34.3%)	56 (26%)
	High	22 (7.1%)	25 (7.2%)	9 (19.1%)	23 (10.6%)	15 (7%)
PI	No plaque	20 (6.4%)	26 (7.5%)	17 (7.6%)	19 (8.8%)	10 (4.7%)
	Mild	119 (38.3%)	149 (43.2%)	79 (35.1%)	87 (40.3%)	102 (47.4%)
	Moderate	112 (36%)	121 (35.1%)	97 (43.1%)	61 (28.2%)	75 (34.9%)
	High	60 (19.3%)	49 (14.2%)	32 (14.2%)	49 (22.7%)	28 (13%)
DMFT	No caries	35 (11.3%)	37 (10.7%)	26 (11.6%)	25 (11.6%)	21 (9.8%)
	With caries	276 (88.7%)	308 (89.3%)	199 (88.4%)	191 (88.4%)	194 (90.2%)

Table 3 presents the oral health indices separately including DMFT, PI, and GI, categorized by the degree of obesity. The mean values of these indices were highest among obese children (GI: 1.47 ± 0,708 / PI: 1.82 ± 0.787 / DMFT: 4.60 ± 3.091 / DT: 4.05 ± 3.130 / MT: 0.17 ± 0.575 / FT: 0.58 ± 1.065), followed by overweight children (GI: 1.30 ± 0.677 / PI: 1.60 ± 0.791 / DMFT: 4.12 ± 2.612 / DT: 3.52 ± 2.531 / MT: 0.09 ± 0.421 / FT: 0.51 ± 1.013). Analysis using the Kruskal-Wallis test revealed a statistically significant relationship between the degree of obesity and the oral health indices GI, PI, DMFT, as well as its components DT (Decayed Teeth) and MT (Missing Teeth) ($P < 0.05$). However, no statistically significant difference was observed for FT (Filled Teeth) ($P > 0.05$) (Table 3). Additionally, Spearman's correlation coefficient indicated a significant positive linear relationship between BMI and oral health indices, demonstrating that higher BMI was associated with worse oral health outcomes
($r > 0$, $P < 0.05$) (Table 4)

Table(3): The relationship between oral factors and BMI groups

Indices	BMI groups	Mean ± SD	Minimum	maximum	*P*-value
GI	Underweight	1.19 ± 0.625	0	2.5	**.001**
	Normal weight	1.11 ± 0.651	0	3	
	Overweight	1.30 ± 0.677	0	3	
	Obese	1.47 ± 0.708	0	3	
PI	Underweight	1.49 ± 0.708	0	3	**<.001**
	Normal weight	1.38 ± 0.744	0	3	
	Overweight	1.60 ± 0.791	0	3	
	Obese	1.82 ± 0.787	0.80	3	
DMFT	Underweight	2.74 ± 2.582	0	10	**<.001**
	Normal weight	3.37 ± 2.471	0	13	
	Overweight	4.12± 2.612	0	12	
	Obese	4.60 ± 3.091	0	14	
DT	Underweight	2.29 ± 2.069	0	8	**.002**
	Normal weight	2.90 ± 2.252	0	12	
	Overweight	3.52 ± 2.531	0	12	
	Obese	4.05 ± 3.130	0	14	
MT	Underweight	0.03 ± 0.180	0	1	**.044**
	Normal weight	0.04 ± 0.266	0	3	
	Overweight	0.09 ± 0.421	0	3	
	Obese	0.17 ± 0.575	0	3	
FT	Underweight	0.42 ± 0.180	0	3	.607
	Normal weight	0.43 ± 0.955	0	7	
	Overweight	0.51 ± 1.013	0	6	
	Obese	0.58 ± 1.065	0	5	

Table(4): Association between oral indices and BMI.

Indices	Spearman correlation coefficient	*P*-value
GI	.089	**.022**
PI	.087	**.025**
DMFT	.153	**<.001**

Discussion:

The relationship between BMI and oral health indices in children and adolescents has gained significant attention in public health research. BMI is a commonly used metric for classifying underweight, overweight, and obesity in this age group and serves as a reliable indicator of body fat. On the other hand, oral health indices such as the DMFT index, PI, and GI are crucial for evaluating the overall health status of the oral cavity. Emerging evidence underscores the bidirectional relationship between BMI and oral health. Elevated BMI levels have been linked to a higher prevalence of dental caries, periodontal diseases, and other oral health complications. Conversely, poor oral health can impair eating habits and hinder the maintenance of a balanced diet, potentially leading to unhealthy BMI levels.

This study aimed to assess BMI and its relationship with oral health indices in adolescents aged 12–14 years in Damascus, Syria. A descriptive cross-sectional design was employed, including a sample of 654 children from various regions. The findings revealed that approximately 30% of the participants were either overweight or obese, the prevalence of dental caries was 89%, gingivitis 88.7%, and poor oral hygiene, as indicated by plaque accumulation, was 93%, highlighting a significant public health concern.

The escalation in poor oral health among adolescent children in Syria is likely linked to the protracted nature of the crisis. Living in conflict zones is known to have detrimental effects on general health, with oral health being no exception. Furthermore, this has precipitated societal health challenges, including a rise in

communicable and non-communicable diseases, difficulties in maternal and child health, and the frightening consequences of conflict (19),(20).

A positive association was observed between BMI and oral health indicators (gingivitis, plaque accumulation, and DMFT index), aligning with findings from previous studies in this field.

The link between childhood obesity and oral health remains inconclusive. In contrast, a well-established connection exists in adults, where obesity is strongly associated with periodontal disease and plaque accumulation. A longitudinal study conducted by Chang et al. in South Korea (1), revealed that individuals with lower BMI had a reduced prevalence of periodontitis compared to those who were overweight or obese. Furthermore, lower BMI was correlated with a decreased prevalence of dental caries. Similarly, a study by Deshpande and Amrutiya (21), demonstrated a direct relationship between higher BMI and increased severity of periodontitis. This aligns with findings by Dhaifullah et al (22), who identified a positive association between elevated BMI and higher rates of periodontitis and plaque accumulation.

The proposed mechanism involves diets rich in fatty foods, which are more common among overweight and obese individuals, potentially contributing to a higher incidence of inflammatory conditions. These conditions trigger a cascade of inflammatory responses, including the production of interleukin-17, which has been implicated in the pathogenesis of periodontal disease (22),(23) While numerous studies have reported a positive relationship between childhood obesity and periodontitis, others have found no such association. For instance, a study by Nascimento et al (24), conducted among Brazilian schoolchildren found no significant link.

Obesity and periodontitis exhibit a bidirectional relationship, with each condition exacerbating the other and contributing to heightened systemic inflammation. Obesity not only accelerates the progression of periodontitis but also increases its potential systemic effects, making these impacts more pronounced in obese individuals compared to those with a normal BMI (25). A study by Modeer et al (26), identified a link between obesity and increased plaque accumulation in Swedish children aged 10–18 years, and Hanau et al (27), agreed with this finding in their research involving Iraqi children aged 6–12 years.

However, these findings contrast with the results of a study conducted by Al-Bitar and Kouchaji (28), which found no significant association between obesity and PI values in children aged 7–8 years in Damascus, Syria. The discrepancies may be attributed to variations in age groups, dietary patterns, and the timing of the studies. Interestingly, it has been suggested that dietary fat intake among overweight and obese children may play a role in reducing plaque accumulation. Fat deposits on the tooth surface form a sticky layer, which may inhibit plaque adherence and accumulation.

Regarding dental caries, This study aligns with the findings of Ashour et al (29), which reported a statistically significant association between dental caries and BMI. Numerous other studies have also demonstrated that individuals with higher BMI are at an increased risk of developing dental caries (30),(31),(32). This relationship is primarily attributed to differences in dietary habits, particularly the consumption of diets rich in unhealthy, sugar- and fat-laden foods, which significantly contribute to the development of dental caries (33). Additionally, metabolic changes linked to obesity may alter the composition and flow of saliva, further elucidating the heightened risk of caries and periodontal diseases in individuals with higher BMI (34). In contrast, this study differed from the results of the study of Alwast et al (35), Idrees et al (36), and Denloye et al (37), which did not identify any significant association between the prevalence of dental caries and BMI.

Several studies have also reported an inverse relationship between the prevalence of dental caries and the degree of obesity, indicating that children with lower body weight have a higher likelihood of developing dental caries (38),(39). These differences can be attributed to variations in sample size and age groups, differences in the methodologies used to assess obesity levels and oral health status, as well as external factors such as race, socioeconomic status, and dietary patterns. The association between malnutrition and dental caries may be explained through mechanisms such as salivary gland dysfunction and alterations in saliva composition, as suggested by Liang et al (38). Furthermore, untreated dental caries can cause significant pain and discomfort in children, leading to reduced food intake. Additional consequences of dental caries, such as infections and sleep disturbances, can adversely impact a child's quality of life, ultimately affecting their overall growth and development (38).

The present study had several limitations. It did not assess participants' oral care behaviors, consider the duration of obesity among obese individuals, or include any interventions

targeting the participants. As highlighted above, it is suggested that future studies should be designed for different ethnicities and ages. Moreover, prospective longitudinal studies should be conducted because dental caries and periodontitis are chronic processes that take a long time to occur. Including data on oral care behaviors, which significantly influence oral health, is crucial for achieving a more accurate and comprehensive understanding.

complex relationship between BMI and oral health in children and adolescents requires multi-faceted strategies. These should include nutrition education, promoting regular physical activity, routine dental checkups, and enhancing access to healthcare services. Public health policies should prioritize integrated care models that tackle these interrelated health challenges. By encouraging healthy lifestyles and improving health outcomes, such measures can support the well-being of children and adolescents.

Conclusions:

Within the limitations of this study, it was observed that higher BMI was associated with an increased prevalence of dental caries, gingivitis, and plaque accumulation. Further research is necessary to explore the impact of oral health behaviors and dental diseases on the development and progression of obesity.

Conflict of Interest Statement:

The authors have no competing interests to report.

Data availability:

The data provided for the results presented in this study is available through the corresponding author upon request.

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