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Mastication in overweight and obese children: A comparative cross-sectional study

Renata Emmanuele Assunção Santos [a], Carol Góis Leandro [a,b], Karla Eveline Ximenes de França [c], Danielly Alves Mendes Barbosa [b], Raquel da Silva Aragão [a,b], Isabeli Lins Pinheiro [b], Kelli Nogueira Ferraz-Pereira [b,*]

[a] *Postgraduate Program in Nutrition, Federal University of Pernambuco, Recife, PE, Brazil*
[b] *Postgraduate Program in Nutrition, Physical Activity and Phenotypic Plasticity, Federal University of Pernambuco, Vitória de Santo Antão, PE, Brazil*
[c] *Postgraduate Program in Child and Adolescent Health, Federal University of Pernambuco, Recife, PE, Brazil*

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Abstract

Objective: The objective of this study was to analyze masticatory characteristics in children from 7 to 10 years, and to compare these characteristics among normal weight, overweight and obese children.

Methods: This is a cross-sectional study, conducted in northeast Brazil, with a sample of 160 children, aged 7 to 10 years. The authors evaluated: nutritional and dental status; food intake; masticatory parameters and orofacial myofunctional characteristics. The children were divided according to nutritional status into normal weight (n = 101), overweight (n = 33) and obesity (n = 26) groups.

Results: The results showed that Obese children had a larger bite size (g) (median = 6.0, Q1-Q3 = 4.0-9.0, p = 0.049) and performed fewer masticatory sequences (median = 3.0, Q1-Q3 = 2.0-3.2, p = 0.024) than children with normal weight (median = 5.0, Q1-Q3 = 4.0-7.0; median = 4.0, Q1-Q3 = 3.0-5.0). Furthermore, obese children finished feeding in a shorter time (s) (median = 62.5, Q1-Q3 = 50.5-70.0, p = 0.039) than normal weight children (median = 66.0, Q1-Q3 = 56.5-78.0) and overweight children (median = 66.0, Q1-Q3 = 58.0-81.5).

Conclusions: The present results suggest that obese children present changes in mastication, evidenced by larger bite-size, performing fewer masticatory sequences and rapid mastication, which may contribute to increased food consumption and the development of excess weight.

Introduction

Chewing is an important element of the ingestion and digestion of food. It is related to feeding behavior by providing

Study conducted at Universidade Federal de Pernambuco, Recife, PE, Brazil.
* Corresponding author.
E-mail: kelli.pereira@ufpe.br (K.N. Ferraz-Pereira).

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motor information to the brain about the food texture and flavor (taste and smell).[1] The extent of the influence of mastication and orosensory response on satiation or satiety and the impact on food intake has been considered in a recent study.[2] Indeed, foods rapidly consumed with insufficient mastication are associated with reduced levels of orosensory signaling during eating, leading to inadequate cephalic-phase responses and delayed onset of satiety.[3]

Research has shown that the highest body mass index (BMI) in children is associated with inadequate processing of chewable material[4]; and children with a higher degree of obesity eat faster and have shorter masticatory cycles.[5] In addition, a previous study found that chewing slowly or increasing the number of masticatory cycles during meals is associated with a lower risk of overweight and obesity during childhood.[6] Most studies have examined the relationship between eating behaviors and obesity risk, but little is known about the masticatory parameters of obese children.

Childhood obesity is an important concern in terms of public health because of its association with cardiovascular disease risk factors, such as; type 2 diabetes mellitus, dyslipidemia, and hypertension.[7] Many of the associated cardiovascular disease risk factors present a strong tendency to persist into adolescence and adult life.[8] Worldwide, about 43 million children under 5 years of age are overweight.[9] In Brazil, about 26.6% of girls and 30% of boys aged 5 to 19 years are overweight.[10] Given that the prevalence of obese children is growing, it is necessary to address the potential contributions of mastication, not only through the risk of becoming overweight but also in children already obese in order to understand whether there are changes in this function and what treatment strategies need to be created.

Understanding the role of mastication as one of the factors related to the onset of obesity is of great importance for the creation of effective therapeutic strategies. Therefore, the aim of the present study was to analyze masticatory characteristics in children from 7 to 10 years and to compare these characteristics among normal weight, overweight and obese children. The hypothesis of the study is that obese children have different masticatory parameters when compared to children of normal weight, as they eat in less time and process less food in the oral cavity.

Methods

Sample

This cross-sectional study, with a comparative approach, was conducted in the municipality of Vitória de Santo Antão, located in the state of Pernambuco, in northeast Brazil. All measurements were carried out during a 10-month period from October 2017 and May 2018, according to the school calendar. The children were chosen through two stages of selection. The first was through a stratified probabilistic sample, according to the number of municipal schools in Vitória de Santo Antão (62 schools) that had students in the age group eligible for the study (7 to 10 years). Of these, three schools were selected, according to the structural availability to carry out the research. In the second stage, the classes with the students in the age group to be studied were identified; then, the children whose parents had consented to have them participate in the study were selected.

Written informed consent from parents or legal guardians was obtained from 160 schoolchildren aged 7-10 years of both sexes (boys, n =84 and girls, n =76). The sample size was calculated using the WinPepi program, based on the nutritional status of young people in the state of Pernambuco- Brazil, with the following criteria: Population estimated at 500 (children aged 7 to 10 years, enrolled in the evaluated schools), confidence interval of 95%, estimated prevalence of 13% of obesity[11] and sample loss of 20%, totaling a minimum sample of 162 individuals. After the evaluations, the children were divided into three groups: normal weight ($\geq$ *Z score* -2 and $<$ *Z score* +1), Overweight ($\geq$ *Z score* +1 and $<$ *Z score* +2) and Obesity ($\geq$ *Z score* +2), according to the reference data BMI-for-age and sex.[12] Thin children were excluded.

Participants with signs of neurological impairment, those undergoing orthodontic treatment or phonoaudiological therapy, those with dry mouth or diseases of the salivary glands, severe malocclusion, or facial surgery were excluded from the study. Children with lesions and craniofacial malformations or using drugs such as anxiolytics, antidepressants, and anticonvulsants were also excluded from the study. This information was collected through a questionnaire sent to parents/ guardians. All study procedures took place in the school facilities.

The study was approved by the Research Ethics committee of the Health Science Centre of the Universidade Federal de Pernambuco (CEP/CCS/UFPE) under project number CAAE 70280017.7.0000.5208, respecting the recommendations of Resolution 466/12 of the National Science Council.

Characterization of nutritional status, dental status, and food intake

The current body weight of the children, lightly dressed and barefoot, was measured to the nearest 0.1 kg with a 100g precision digital scale (Lider, São Paulo, Brazil). Stretched stature was measured to the nearest 0.5 cm using a portable stadiometer (Sanny, São Paulo, Brazil) with each subject's shoes off, feet together, and head in the Frankfurt horizontal plane. The BMI was calculated using the standard formula [weight (kg)/height2 (m)]. Data collection was conducted by previously trained technicians, following the norms of the Measurement Standardization Manual.[13] The calculation of the BMI-for-age Z score was completed using the Anthro computer software (version 3.2.2), and the nutritional status was classified according to the growth standards of the World Health Organization.[12]

Dental status was characterized by a single dentist trained and qualified during a pilot study. Theoretical training was carried out 3 days before qualification to ensure an understanding of the criteria and codes for the various conditions to be observed and recorded. The qualification was performed with 15 children and aimed to provide a consistent and uniform assessment during the survey.

The oral exam was conducted in a classroom, under ambient light, using a tongue depressor. The number of decayed, missing, and filled teeth (DMFT) was quantified. Deciduous

and permanent teeth were considered together since the children had mixed dentition. Dental malocclusion was also evaluated, through the use of the malocclusion index as recommended by the WHO in 1987,[14] which classifies dental occlusion as normal, mild malocclusion, and moderate/severe malocclusion. Children with moderate/severe malocclusion were excluded.

To analyze the type of food that was consumed by children, the authors used the Food Consumption Markers form of the Food and Nutrition Surveillance System (SISVAN) of the Brazilian Ministry of Health. This form was answered by the children through an interview.[15] In the first part of this form, it is asked if the child has the habit of having meals while watching TV, using the computer and/or cell phone, as well as the number of meals they have throughout the day (1 – 3; or 4 – 6 times/day). In the second part of the form, the children are asked if the day before the interview they consumed beans, fruits, vegetables, processed foods, sweetened beverages, and ultra-processed foods in general, such as instant noodles, snacks, and cookies.

Analysis of masticatory parameters and orofacial myofunctional evaluation

These evaluations were conducted using a video recording with a digital camera (Sony Cyber-Shot DSC-HX300, São Paulo, Brazil), during the mastication of a chocolate-flavored biscuit (Nestlé Brazil Ltda., São Paulo, Brazil). The mastication exam was recorded with the child sitting in a backrest chair, feet positioned on the floor, at a standard distance (1 m) from the camera. Participants were evaluated between 7:00 and 7:30 in the morning, after 12 h fasting and a 24 h period without exercise.[16] Briefly: images were recorded when the child started to chew (open mouth) a stuffed biscuit (free mastication) and stopped when the food was completely swallowed. Masticatory parameters were determined by quantifying the physiological parameters of mastication, as detailed in other studies,[16] as described in Table 1. The bite-size was measured according to a previous study,[17] using a piece of bread. Children were instructed to take two bites of the bread. Initial weight (IW) and final weight (FW) of the bread was recorded and data from the bite size was expressed in grams.

To evaluate orofacial myofunction, the protocol of expanded scores (OMES-e) was used. The OMES-expanded permits the assessment of appearance/posture and mobility of the stomatognathic system and of functions such as breathing, swallowing, and mastication.[18] In the present study, only the mastication domain was evaluated, similar to the study by Pedroni-Pereira and collaborators.[19] The children were instructed to chew a chocolate-flavored biscuit (Nestlé Brazil Ltda., São Paulo, Brazil) and during mastication, the following were observed: food incision (incisor/canine/premolar/molar bite); type of mastication (unilateral/bilateral); movements of the head or other parts of the body during the masticatory function; escape of food during mastication; and duration of mastication. In this protocol, the higher the score found, the better the orofacial myofunctional performance.

The analysis of the masticatory parameters and orofacial myofunctional was performed by two trained and qualified examiners. Theoretical training was offered by a specialist in the area and aimed to ensure a good understanding of the criteria. Codes were established for the various conditions to be observed and recorded. Qualification was performed with 15 children, with the aim of providing a consistent and uniform assessment by the examiners. The intraclass correlation coefficients (ICC) were calculated for each parameter, and the differences between the evaluators were resolved in a joint analysis.

Table 1 Description of masticatory parameters.

Parameters	Description
Number of masticatory sequences	Number of masticatory movements performed from the incision to the swallowing of the food
Number of masticatory cycles	Number of open/close movements of the mandible, for swallowing
Chewing rate (cycles/min)	Number of open/close movements of the mandible per minutes
Feeding Time (s)	Time taken to ingest completely the food
Bite size (g)	The amount of food per bite

Images were evaluated by two trained examiners.

Statistical analysis

Exploratory data analysis was used to test the assumption of normality in all data distributions, using the Kolmogorov-Smirnov test and Levene's equal variance test. Categorical variables were described by means of absolute frequency (n) and relative frequency (%), and numerical variables by means of the median and interquartile ranges (Q1–Q3). The intraclass correlation coefficient was determined to evaluate the concordance between the evaluators during the analysis of the parameters of mastication, according to a previous classification[20] (Table 2). For categorical variables, Pearson's chi-square and Fisher's exact tests were used. When comparing the masticatory parameters according to the "nutritional status" factor, the Kruskal-Wallis test was used, followed by the Dunn post-test, since the data did not present a normal distribution. All analyses were carried out using SPSS version 17.0 (SPSS, Inc. Chicago, IL) and statistical significance was set at $p < 0.05$.

Results

The descriptive analyses of children according to nutritional status (normal weight, overweight, and obesity) and dental status are shown in Table 3. The high percentage of overweight/obese children is notable (n = 59; 36.9%). As expected, overweight and obese children showed higher body weight and BMI than the children with normal weight. Moreover, the analysis of the children's food intake

Table 2 Intraclass correlation coefficients (ICC) of the analysis of the masticatory parameters and orofacial myofunctional evaluation in children from 7 to 10 years of age, measured by two examiners.

		Examiner 1		Examiner 2		
Masticatory Parameters	n	Median	Q1-Q3	Median	Q1-Q3	ICC
Masticatory Sequence	160	4.0	3.0 — 5.0	3.5	3.0 — 5.0	0.954
Masticatory Cycles	160	18.0	15.0 — 23.7	20.0	16.0 — 26.7	0.955
Chewing rate (cycles/min)	160	60.9	52.1 — 67.9	69.5	61.1 — 78.7	0.764
Feeding Time (s)	160	65.0	55.5 — 77.0	65.0	55.5 — 77.0	1.000
OMES-e Score	160	16.0	15.0 — 20.0	16.0	14.0 — 19.5	0.774

(Supplementary Table) showed that the food intake of different foods and the number of meals throughout the day were similar among the groups. About 70% of children reported eating while watching TV or other distractors, regardless of their nutritional status. A high percentage of children ate 4-6 times a day, with a preference for sugary drinks, processed foods, and stuffed cookies.

The analysis of agreement between the evaluators for the evaluation of the physiological parameters observed in the mastication and orofacial myofunctional evaluation, ranged from substantial (chewing rate and OMES-e Score) to perfect (Feeding Time) (Table 2). When comparing the masticatory parameters of children according to their nutritional status (Figure 1), the authors found that obese children chew differently than normal-weight children. This is because obese children have a larger bite size (g) (median = 6.0, Q1-Q3 = 4.0 — 9.0, p = 0.049), perform fewer masticatory sequences (median = 3.0, Q1-Q3 = 2.0 — 3.2, p = 0.024) and have a shorter feeding time (s) (median = 62.5, Q1-Q3 = 50.5 — 70.0, p = 0.039) compared to normal weight children (median = 5.0, Q1-Q3 = 4.0 — 7.0; median = 4.0, Q1-Q3 = 3.0 — 5.0; median = 66.0, Q1-Q3 = 56.5 — 78.0) (Figure 1A, E and D). Furthermore, obese children also finished the feeding in a shorter time (s) (median = 62.5, Q1-Q3 = 51.5 — 70.0, p = 0.039) than children with overweight (median = 66.0, Q1-Q3 = 58.0 — 81.5) (Figure 1D). However, there were no differences in the other parameters of masticatory sequence and OMES-e score when groups were compared.

Table 3 Characterization of the samples of children from 7 to 10 years of age, with normal weight, overweight and obesity, according to sex, age, anthropometry, and dental status.

	Normal weight		Overweight		Obesity	
	n	%	N	%	n	%
Children	101	63.1	33	20.6	26	16.3
Female	49	48.5	18	54.5	9	34.6
Male	52	51.5	15	45.5	17	65.4
Age						
7 years	31	30.7	7	21.2	8	30.8
8 years	37	36.6	14	42.4	7	26.9
9 years	33	32.7	12	36.4	11	42.3
Dental malocclusion						
Normal	80	64.5	25	20.2	19	15.3
Mild	21	58.3	8	22.2	7	19.4
	Median	**Q1-Q3**	**Median**	**Q1-Q3**	**Median**	**Q1-Q3**
Body weight (kg)	25.9	24.2-29.0	32.0[c]	29.6-37.6	44.3[a,b]	37.0-48.9
Body height (cm)	129.0	125.0-134.0	131.0	126.0-137.0	135.5[b]	126.7-140.5
BMI (kg/m^2)	15.6	14.5-16.7	19.0[c]	18.2 — 19.9	23.9[a,b]	21.7-25.2
BMI/age Z Score	-0.1	-0.8-0.6	1.5[c]	1.1-1.5	2.6[a,b]	2.5-3.4
Decayed Teeth	0.0	0.0 — 0.0	0.0	0.0 — 0.0	0.0	0.0 - 0.0
Missing Teeth	1.0	0.0 — 2.0	1.0	0.0 — 2.0	1.0	0.0 — 2.0
Filled Teeth	0.0	0.0 — 2.0	0.0	0.0 — 2.0	0.0	0.0 — 2.0

Comparison between categorical variables: Pearson's Chi-Square test; Comparison between numerical variables: Kruskal -Wallis test. Dunn's Post-hoc Test for multiple comparisons.

[a] Significant differences between obesity group and overweight group ($p < 0.05$).

[b] Significant differences between obesity group and normal weight group ($p < 0.05$).

[c] Significant differences between overweight group and normal weight group ($p < 0.05$).

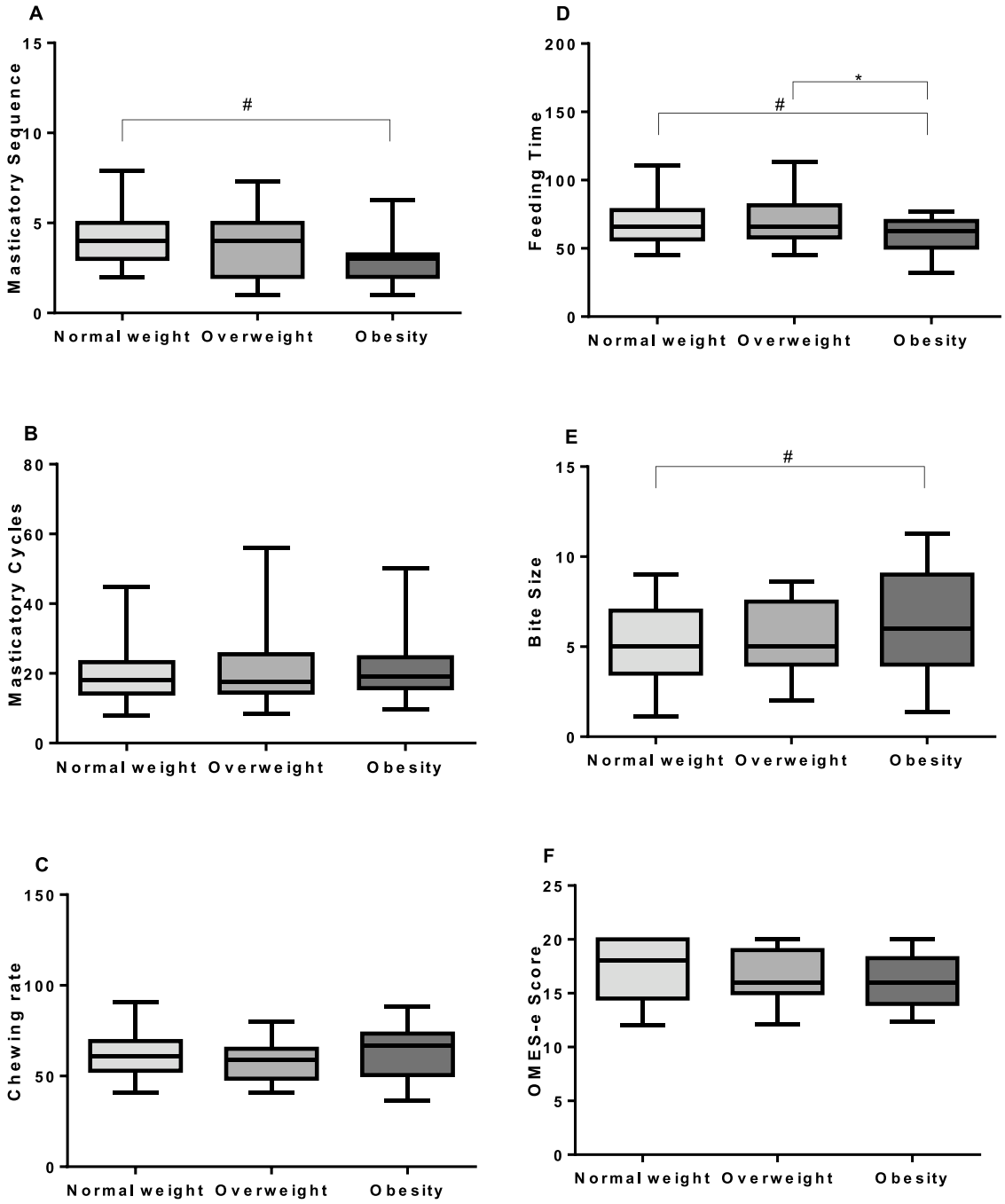

Figure 1 Comparison between masticatory parameters of children from 7 to 10 years of age, classified according to nutritional status in normal weight, overweight and obesity. Boxplot shows median ± 25% (boxes) and the 5th and 95th percentiles (whiskers). Kruskal-Wallis test and Dunn's Posttest.
#Significant differences between obesity group and normal weight group ($p < 0.05$).
*Significant differences between overweight group and normal weight group ($p < 0.05$).

Discussion

The authors analyzed masticatory characteristics in children from 7 to 10 years, comparing these characteristics among normal weight, overweight and obese children. The main findings of this study were that obese children perform fewer masticatory sequences, eat in less time and bite food in larger pieces, compared to normal-weight children. The findings of this article contribute to clarifying the relationship between mastication and overweight/obesity in children. The data from this study may result in contributions to help build more effective treatment strategies for childhood obesity reduction that affect countless children around the world.

Aligned with previous studies, regardless of their BMI, most children showed a preference for sweetened beverages, instantaneous noodles, package chips, salty crackers, stuffed biscuits, and sweets.[21] The consumption of these foods is closely related to the onset of obesity. In the present study, irrespective of their nutritional status, 70% of children had meals while viewing television, while on a computer, or when using a cell phone. This behavior is classical among children, and it has been considered a reasonable predictor of bad eating habits during adolescence, increasing the risk of becoming obese in adulthood.[22] In previous studies, teenagers have been observed to ingest more soda when the television was on. The presence of a computer or another 'distractor' such as music and cell phone-induced a high consumption of industrialized food.[23] Thus, the deviation of attention during meals seems to be directed toward visceral sensations of satiety, rather than the hypothalamus control generated during a meal, leading to overeating.

In the present study, obese children were shown to have different masticatory parameters when compared to normal-weight children, with a larger bite size, reduced masticatory sequences and quicker feeding duration. A previous study demonstrated that children (8 — 12 years old) with overweight ate faster, had greater bite size, and presented a rapid acceleration of their eating rate towards the end of the meal when compared to normal weight children.[24] For young children (4 — 6 years old), a rapid eating style, defined by increased mouthfuls of food/min, predicted overweight status at age 6 years and excess weight gain from ages 4 to 6 years, suggesting that this may be a behavioral marker for the development of childhood obesity.[25] These findings can be explained by the association between mastication and satiety, where a child who chews less and/or in less time takes longer to be satisfied with the amount of food eaten. This may contribute to the intake of more foods, favoring an increase in BMI.[26]

Despite the differences in children's masticatory sequence, bite size and feeding time, as found in the present study, the authors found no significant effect on the OMES-e score when the groups were compared. OMES-e score is a protocol produced to determine the masticatory type, feeding time/frequency, abnormal movements, and bite force.[26] It is considered that the higher the score, the better the function.[26] In adolescents, a study found that those with excess weight show more changes in the orofacial myofunctional aspects of mastication.[19] With children, on the other hand, data on the orofacial myofunctional characteristics of the obese are scarce in the literature. According to Mason,[27] disturbances in the orofacial myofunctional characteristics may have a negative impact on posture and oral functions, including masticatory function. The reduction of muscle tonus in the phonoarticulatory organs reduces the efficiency of masticatory movements, impairing mastication.[28] Thus, the authors observed that obesity may be related to impairments in the myofunctional characteristics of individuals; however, more studies with obese children are necessary.

The novelties of this study are related to (1) The age group analyzed, since the existing studies did not analyze the chewing of children in the school-age group, from 7 to 10 years old, exclusively; (2) The analysis of physiological parameters of mastication in isolation, since the few existing studies analyzed the masticatory performance of obese children through the study of food processing and/or chewable materials; (3) The analysis of food consumption in parallel with the analysis of masticatory behavior. Thus, the authors observed that despite the children consuming the same types of food, there are differences between the chewing of obese children and those with adequate weight. Notwithstanding the relevance of the present results, the authors must recognize as a limitation the fact that the study had a cross-sectional design, which provides only a punctual assessment of the characteristics of the population and does not allow establishing a causal relationship, which highlights the need to conduct a longitudinal study.

The present study corroborates the hypothesis that obese children present differences in mastication when compared to children with normal weight. The authors' findings contribute to clarifying the relationship between mastication and obesity, addressing the importance of the association between changes in masticatory parameters, food intake and nutritional status, especially in childhood.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgments

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jped.2022.07.008.

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