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Original articles

Association between waist-to-height ratio and masticatory function in predicting childhood obesity

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ABSTRACT

Purpose: to evaluate masticatory function in children according to the waist-to-height ratio.

Methods: a cross-sectional study with 92 public school students aged 7 to 12 years of both sexes from a Brazilian city. They were divided into the following groups: waist-to-height ratio (WHtR) > 0.5 (N = 27) and WHtR < 0.5 (N = 65). Researchers considered their data on sex and age and evaluated their anthropometric parameters, masticatory performance, and electrical activity of the masseters. Pearson's chi-square test compared categorical variables, and Student's parametric t-test for independent samples compared numerical variables. In case of deviation from normal distribution, the Mann-Whitney test was used. Significance was set at $p < 0.05$.

Results: children with WHtR > 0.5 had greater resting electrical activity of the right and left masseters and shorter meals than children with WHtR < 0.5.

Conclusion: obese children have lower electrical activity of the masseters during chewing, contributing to shorter meals when compared to normal-weight children.

Keywords: Pediatric Obesity; Mastication; Waist-Height Ratio

INTRODUCTION

Obesity is a complex multifactorial disease defined by excessive adiposity linked to an increased risk of chronic non-communicable diseases[1]. According to the World Health Organization[1], approximately one billion people worldwide are obese. Obesity is also commonly seen in the Brazilian population, especially in children. In 2022, the Ministry of Health reported that approximately 3.1 million children under 10 years old are affected by obesity[2].

Childhood obesity is characterized as a public health problem[3] due to its alarming rates and its physical, psychological, metabolic, and behavioral consequences[3-6]. The latter two include the masticatory function, whose changes are related to overweight/obesity in the literature[7], increasing the probability of children remaining obese in adulthood.

Chewing is the act of biting, grinding, and pasteurizing food. It is the initial phase of the digestive process, mechanically degrading and reducing food to a swallowable size[8]. Chewing is fundamental in the cephalic phase of eating behavior due to the sensory stimulation of food contact with the oral cavity[9]. The first study[7] to describe a specific chewing style in obese individuals was published in 1996. The findings proposed that these people perform fewer chewing cycles, often unilaterally, eat faster, and ingest chewable material in larger sizes.

Thus, food ingested quickly with insufficient chewing is associated with reduced orosensory signaling during feeding, delaying satiety[10]. In the current scenario, the high prevalence of childhood obesity requires an understanding of the masticatory function as a factor that affects satiety and the risk of weight gain, as well as an investigation into whether obese children have masticatory changes and what strategies can be formulated for treatment.

Anthropometric measurements are used to categorize individuals as normal-weight or obese because they are easy to understand, low-cost, and minimally invasive methods[11]. They include the waist-to-height ratio (WHtR), which assesses obesity and central adiposity through the ratio of the waist circumference to the person's height, with a single cutoff point of 0.5 for both sexes and all age groups. Its justification is that there is an admissible degree of fat in the abdominal region for each height. According to the study proposed in 2018[12], children with a WHtR value > 0.5 are 5.6 times more likely to be obese than those with a WHtR < 0.5.

Over time, studies relating mastication to obesity have been controversial due to their different methods and protocols. In the meantime, the lack of studies evaluating how mastication relates to risks of overweight/obesity in children, according to WHtR, makes it impossible to establish cause-and-effect relationships. This study aimed to evaluate the masticatory function in children according to their WHtR. It hypothesized that children with WHtR > 0.5 perform worse in the masticatory function than those with WHtR < 0.5.

METHODS

This descriptive, quantitative, cross-sectional study had a sample of 92 public school students aged 7 to 12 years, of both sexes, from a Northeastern Brazilian city. It began only after being approved by the Research Ethics Committee of the Department of Health Sciences at the Universidade Federal de Pernambuco (CEP/CCS/UFPE), PE, Brazil, under evaluation report number 3.654.541 (CAAE 70.280.017.7.0000.5208), in accordance with Resolution 466/12 of the Brazilian National Health Council.

Consent was first obtained from the children's parents/guardians, allowing them to participate in the study if they wished to do so. The study included children of both sexes aged 7 to 12 years and excluded those with signs of facial surgery, craniofacial malformations, or neurological impairment, a history of orofacial myofunctional therapy and orthodontic treatment, and underweight children, girls who had already menstruated, and all those who refused to participate in the research.

The sample size for this population was calculated in the WinPepi program using the following criteria: estimated population of 160, 95% confidence interval, 16% estimated prevalence (according to previous studies by this research group)[13], and 20% sample loss. This totaled a sample of 113 students, excluding children with incomplete or poorly recorded data, making new analyses impossible. Through the calculation, this study's database included 92 children aged 7 to 12.

Anthropometric assessment

Anthropometric measures were assessed using height and waist circumference to classify the children's nutritional status. A compact Slim-Fit® stadiometer fixed to the wall measured the children's height, and a tape measure provided their waist circumference. The latter was measured at the point of the smallest difference between the last rib and the iliac crest, using as reference an imaginary horizontal line through the midpoint between the lower edge of the last rib and the iliac crest.

The study calculated the children's WHtR based on their waist (cm) and height (cm) in the anthropometric assessment. After the assessment at school, the sample was divided into two groups: WHtR > 0.5 (N = 27) and WHtR < 0.5 (N = 65), based on the WHtR reference data for sexes and ages[12]. The study considered ratios greater than 0.5 as associated with an increased risk of obesity.

Assessment of masticatory performance

The myofunctional mastication assessment was performed by observing videos of mandibular movements as they chewed Bono® brand sandwich cookies (Nestlé Brasil Ltda., Marília, SP, Brazil). The validated Orofacial Myofunctional Evaluation Protocol with Scores-extended (OMES-E)[14] was applied to analyze the videos, observing the following aspects of mastication, according to the protocol: food incision (biting with incisors, canines, premolars, or molars), bite size, chewing type (unilateral/bilateral), movements of the head or other parts of the body during mastication, food spillage when chewing, chewing duration, and the number of masticatory cycles. Their chewing rate and masticatory frequency were recorded considering the first masticatory sequence. The protocol considers 0 as the worst result and 10 as the best masticatory performance.

Chart 1. Description of the masticatory parameters analyzed in children

Parameters	Description
Number of masticatory sequences	The number of chewing movements performed from food incision to swallowing.
Number of masticatory cycles*	The number of jaw opening/closing movements per swallow.
Mastication time*	The time used to perform jaw opening/closing movements.
Masticatory frequency (cycles/s)	The number of jaw opening/closing movements per second (number of chewing cycles/time in seconds).
Length of meal (s)	The time needed to completely ingest the food.
Mastication rate (cycles/min)	The number of jaw opening/closing movements per minute (total number of chewing cycles/ chewing time in minutes).

*Considering only the first masticatory sequence.

Statistical analysis

The data analysis included the construction of the database in Excel 2016. The categorical variables were described with absolute (n) and relative frequency (%), and numerical variables with parametric analyses of means, standard deviations, medians, and confidence intervals. The normality of the data was tested using the Kolmogorov-Smirnov test. Nonparametric analyses or logarithmic transformations were used for those that deviated from the normal distribution. Categorical variables were compared with Pearson's chi-square test, and numerical variables with the parametric Student's t-test for independent samples. The Mann-Whitney test was used in cases of deviation from the normal distribution. The statistical significance level was set at $p \leq 0.05$. The analyses were performed using SPSS®, version 20.0.

RESULTS

Table 1 shows the characterization of children classified according to their WHtR. No differences were found regarding sex or age.

Table 2 shows the electrical activity of the masseter muscle and the children's masticatory performance, according to their WHtR. It was found that children with WHtR > 0.5 used fewer masticatory sequences and cycles and had shorter meals than children with WHtR < 0.5.

Table 1. Characterization of children classified according to waist-to-height ratio as WHtR < 0.5 and WHtR > 0.5. Recife - PE, Brazil, 2024

	WHtR < 0.5 (N = 65)		WHtR > 0.5 (N = 27)		P
	n	%	n	%	
Children	65	70.7	27	29.3	
Sex[a]					
Females	42	73.7	15	26.3	0.482
Males	23	65.7	12	34.3	
Age[b]					
7 years	2	40.0	3	60.0	0.324
8 years	14	77.8	4	22.2	
9 years	11	64.7	6	35.3	
10 years	27	67.5	13	32.5	
11 years	9	90.0	1	10.0	
12 years	2	100.0	0	0.00	

[a] Fisher's exact test. [b] Pearson chi-square test.
Caption: WHtR = waist-to-height ratio.

Table 2. Electrical activity of the masseter muscle and masticatory mandibular movements of children classified according to waist-to-height ratio. Recife - PE, Brazil, 2024

	WHtR < 0.5 (N = 65)		WHtR > 0.5 (N = 27)		p
	Median	IQR	Median	IQR	
Masticatory sequences[b]	63.00	52.75-86.00	58.00	46.50-66.50	0.092
Masticatory cycles[b]	21.00	14.00-29.00	25.00	17.75-34.75	0.172
Mastication time (s)[b]	16.35	10.23-21.91	17.25	12.33-25.58	0.294
Masticatory frequency (cycles/s)[b]	1.37	1.18-1.52	1.28	1.18-1.50	0.563
OMES-E[b]	20.00	16.00-20.00	19.00	16.00-20.00	0.626
Length of meals (s)[b]	72.00	59.75-91.50	64.00	53.50-72.75	0.046*
Masticatory rate (cycles/min)[a]	64.50	±10.50	65.17	±10.42	0.780

[a] t-test (data expressed as mean ± standard deviation). *p < 0.05. [b] Mann-Whitney test (data expressed in median and interquartile range)
Caption: WHtR = waist-to-height ratio.

DISCUSSION

This study aimed to evaluate masticatory function in children aged 7 to 12 years according to their WHtR. The findings show that obese children (WHtR > 0.5) have shorter meals than normal-weight children. These findings suggest that obese children have changes in masticatory performance, influencing their food consumption and anthropometry.

The anthropometric characterization of the target audience shows that 29.3% were overweight/obese (N = 27). These results exceed those published in Brazil by the Food and Nutrition Surveillance System in 2019, in which 14.96% of children aged 5 to 10 years were overweight, 8.22% were obese, and 4.97% were severely obese[15]. Consistent with the findings of this research, in which 34.3% of boys and 26.3% of girls were obese, a 2017 study[16] showed that 30% of boys and 2.6% of girls were overweight in childhood. These data are important for creating strategies to combat and prevent childhood obesity and keep this condition from perpetuating. Studies show a greater probability of obese children remaining obese in adulthood[17] despite the age at which obesity developed.

Obese children have fewer chewing movements from incision to swallowing and fewer jaw opening/closing movements per second. It is known that the chewing function is coordinated by a muscle group comprising the masseter, temporalis, and buccinator[18]. Chewing is characterized as the first stage of digestion, grinding food into smaller particles for better absorption of nutrients in the gastrointestinal tract[19]. It is also related to eating behavior due to the sensory stimulation of food contact with the oral cavity, releasing appetite hormones, such as insulin and ghrelin[9]. Therefore, it can be considered that the obese children in this study, because they ingest food in larger portions, eat faster, perform fewer chewing cycles, and frequently chew unilaterally, also have changes in their eating behavior because of the low release of hormones due to the low contact of the chewable material with the oral cavity.

In this study, 70% of children, regardless of their nutritional status, ate their meals using screens, such as mobile phones or television. This increasingly common habit among children has been considered a likely cause of poor eating habits in adolescence, increasing the risk of them becoming obese in adulthood[20]. The presence of screens or other distractions induced a high consumption of processed foods in this group of adolescents. Consequently, shared attention during meals leads to excess food consumption due to satiety hormone inhibition[21]. In other words, it is necessary to instruct children and their parents/guardians about the harm caused by eating while using distractions.

Regarding the muscles involved in chewing, a study[13] detailed that the masseter of obese children has greater electrical activity at rest. Therefore, there is an increase in muscle activity at rest, leading to fatigue and impaired chewing performance. This finding explains why obese children (WHtR > 0.5) in this study used shorter chewing and shorter meals – their masseters got fatigued more quickly when chewing, causing the child to eat more quickly. Despite consuming a larger amount of food, it is believed that their masticatory muscles are not adequately stimulated to grind the food they ingest[21].

A previous study[20] indicates that people with chewing disorders are more likely to change their diet to avoid foods that are difficult to chew. This preference can result in an imbalanced food intake, with a preference for soft and easy-to-chew foods, such as ultra-processed foods[6]. In contrast, foods that are hard to chew, such as those rich in fiber, lead to a lower overall food intake when compared to soft foods. Therefore, it can be inferred that the obese children in this study with chewing disorders have eating habits that facilitate their chewing, leading them to consume more foods that are easier to chew (such as fast food, snacks, and sugary ones associated with higher caloric intake) and fewer fruits and vegetables.

Despite the differences in chewing patterns, such as larger bite size, reduced chewing sequences, and faster eating duration, obese children were not significantly different from normal-weight children in the OMES-E score. This protocol, characterized by its scores, aims to determine the chewing type, feeding time/frequency, abnormal movements, and bite force – the higher the score, the better the function[14].

Similar to the current study, another one[22] shows that obese children aged 8 to 12 years ate faster, with larger bite sizes, and at a faster rate than normal-weight children. In line with these findings, overweight children aged 6 to 11 years ate faster, with larger food portions and little chewing time, indicating that this behavior may be a marker for childhood obesity[23]. This condition is explained by the association between chewing and satiety, as children who chewed with less time and quality took longer to feel satisfied with the material ingested. Moreover, a previous study[24] showed that chewing slowly, with more chewing cycles during meals, was associated with a lower risk of childhood overweight and obesity.

It is important to note that chewing is directly related to adequate orofacial growth[25]. It increases the orofacial muscle force on the teeth, adequately developing the hard structures. These stimuli depend on the bolus texture, hardness, and volume, and sufficient and adequate force for the different consistencies ingested. When these prerequisites are not practiced, orofacial growth may be compromised, culminating in poor oral motor function[26]. In other words, understanding and teaching the correct chewing patterns to obese children prevent childhood obesity through longer chewing time and cause adequate facial bone growth[27].

This study corroborates the hypothesis that obese children have masticatory changes compared to normal-weight children. Some limitations should be acknowledged: (1) it was impossible to assess whether the study children's masticatory changes predisposed them to obesity or whether obesity changed their mastication; (2) the children's breathing was not assessed. It is known that the breathing pattern influences masticatory performance – the speed, rhythm, and lip posture during mastication may be abnormal due to mouth breathing, which is rather prevalent in the study's age group. The findings of this study may help develop plans to combat and prevent childhood obesity.

CONCLUSION

According to the WHtR, obese children performed worse in mastication due to shorter meals and greater muscular activity of both masseters at rest. These results may contribute to the scientific community developing methods to combat and prevent childhood obesity.

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LCMG, ILP: Project administration; Resources; Supervision.

IJASC: Conceptualization; Formal analysis; Writing - Original draft.

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Data sharing statement:

The data used in this article were collected for this research only and cannot be made publicly available.