Physiology & Behavior 163 (2016) 115–122

Contents lists available at ScienceDirect

Physiology & Behavior

journal homepage: www.elsevier.com/locate/phb

Assessment of the differences in masticatory behavior between male and female adolescents

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HIGHLIGHTS

- The results support the existence of sex differences in masticatory behavior.
- Eating fast does not necessarily imply worse masticatory performance.
- The results may help the assessment of sex-specific treatment outcomes.
- Normative data may be useful when considering different populations and conditions.

ARTICLE INFO

Article history:
Received 28 February 2016
Received in revised form 28 April 2016
Accepted 29 April 2016
Available online 30 April 2016

Keywords:
Mastication
Sex differences
Adolescent

ABSTRACT

Chewing behavior may show sex differences; thus, the present study aimed to compare the masticatory aspects and the prediction of masticatory performance between male and female adolescents. Ninety-one healthy subjects (47 girls, 44 boys), caries-free and aged 14–17 years, were included. Masticatory performance and maximal bite force were evaluated using a color-changeable chewing gum and digital gnathodynamometer, respectively. Masticatory behavior was assessed by the subjective aspect of the quality of the masticatory function (validated questionnaire) and the Orofacial Myofunctional Evaluation with Scores expanded (OMES-e) was used to determine chewing time, frequency of chewing cycles and other aspects. Salivary flow rate was also assessed. The physical examination involved measurements of facial morphometry, body weight, height, skeletal muscle mass, and dental/occlusal evaluations. It was observed that boys showed larger facial dimensions, higher bite force and chewing frequency and better masticatory performance than girls. They also showed shorter chewing time, fewer chewing cycles and lower score for OMES-e (that is, more changes in orofacial myofunctional aspects). Bite force showed a weak correlation with skeletal muscle mass only in boys ($r = 0.3035$; $p = 0.0451$). The masticatory performance was dependent on the bite force in boys (Adj $R^2 = 19.2\%$; Power = 84.1%); among girls, masticatory performance was dependent on the frequency of chewing cycles and masticatory behavior (subjective aspect) (Adj $R^2 = 34.1\%$; Power = 96.1%). The findings support the existence of sex differences in many masticatory aspects of function and behavior, hence the importance of considering sex differences when evaluating masticatory function and myofunctional therapy outcomes among young subjects.

1. Introduction

Chewing is one of the most important functions of the stomatognathic system and it is meant to reduce the size of food particles to prepare them for swallowing and digestion [52]. Biting and chewing food is a multisensory task that requires a high level of coordination of all structures of the mouth. During chewing, the sensory contact with food stimulates saliva production and satiety signals are transmitted to the brain, which are triggered by gastric distension and the release of gut factors, including cholecystokinin [32], preparing the organism to assimilate the ingested nutrients [43]. At the same time, it involves enjoyable sensations related to taste and the pleasure of eating [41].

The reduction of food particles is determined by a complex multifactorial process, which depends on the force of masticatory muscles (bite

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http://dx.doi.org/10.1016/j.physbeh.2016.04.053
0031-9384/

force) and their coordination, the craniofacial morphology and the number of occluding pairs of teeth, once they comprise the occlusal area where food is fragmented [52]. The properties of the food being chewed, in terms of hardness, fat content, food portion size and food structure, are also important [5], as the number of chewing cycles increases with food hardness [19] and decreases with the fat content of the food [11].

Masticatory function may be evaluated by objective and subjective measures. Whereas objective measures such as masticatory performance and efficiency and evaluation of bite force can provide specific and reliable values of the masticatory process, questionnaires may help to understand an individual's chewing behavior and diagnose any difficulties while performing the function [20,21,28]. Using a validated questionnaire, it is possible to assess if the subject avoids a certain type of food because of its size or consistency.

Males and females may show differences in some aspects of their feeding and masticatory behavior. With regard the comparison of masticatory movements' path and rhythm, Tamura and Shiga [50]) reported differences for spatial (vertical and lateral movements) and temporal parameters (opening, closing, occluding and cycle times) between male and female adults. Sex differences for maximal bite force were also previously found in adults [39,47]; in young subjects, this issue has not been properly explored, and the few previous studies found did not evaluate the interrelationship between masticatory performance and chewing behavior [6,53].

The understanding of the mechanisms involved in the masticatory function allows health professionals to act on the prevention and treatment of eating disorders and facial and dental impairments. The hypothesis to be tested was whether masticatory parameters and chewing behavior may show sex differences in healthy adolescents. Therefore, the purpose of this study was to compare the masticatory behavior and the prediction of masticatory performance between male and female adolescents.

2. Materials and methods

2.1. Sample selection

The reporting of this research follows the STROBE recommendations for reports of observational studies [29]. This study was approved by the Ethics Committee of the School of Dentistry of Piracicaba (protocol n. 152/2014), Brazil. The procedures and possible discomforts or risks were fully explained to the adolescent and their parents/guardians. Each subject and his parent/guardian gave voluntary consent to participate in this research by signing an informed assent form and a parental/guardian consent form, respectively, after having their questions and concerns addressed.

Approximately 1435 students aged 14–17 years of five Public Schools of Piracicaba were invited to participate in this study. Only 337 agreed to participate: 217 were excluded from the eligibility criteria, 29 left the school in the middle of the survey and the final sample consisted of 91 adolescents (47 girls and 44 boys) of three schools located in the downtown area and two schools located on the outskirts of the city. Sample size calculation was based on results from a previous study of our group which evaluated the relationship between bite force, sex, skeletal muscle mass and other independent variables in children [2]; considering a regression coefficient equal to 3.379, power = 0.80, and alpha level of 0.05, it was found that 88 subjects (44 subjects of each sex) would be necessary to perform such evaluation. All evaluations were conducted in classrooms or in school libraries during the year 2015.

2.2. Anamnesis and oral examination

Anamnesis consisted of an interview with the adolescent to assess the demographic data (personal data, self-reported ethnicity: white or Afro-Brazilian), dental and medical experiences, presence of parafunctional habits (finger sucking, nail biting, sleep bruxism, mouth breathing, snoring, asthma and bronchitis); history of orthodontic treatment and chronic use of medications or drugs [2,34]. This information was useful to check the homogeneity of the sample and exclusion criteria.

The dental health status was evaluated using the DMFT index (total of decayed, missing and filled teeth), following the World Health Organization criteria, by a calibrated examiner (DSA) [55]. The presence of periodontal pockets was recorded according to the Community Periodontal Index [55], and the index teeth were: 11, 31, 16, 26, 36, 46.

The presence of symptoms of temporomandibular dysfunction (TMD) was screened as proposed by the American Academy of Orofacial Pain [10]. The questionnaire consisted of 10 questions that individually asked about temporomandibular joint (TMJ) sounds and pain, masticatory muscle pain or fatigue of the jaw and difficulty during mouth opening, which ultimately could interfere in the masticatory function. As previously proposed by Gonçalves et al. [13]), the subjects who reported the presence of pain were excluded.

Finally, the inclusion criteria for this convenience sample were: adolescents with permanent dentition (excluding third molars) and those presenting normal weight classified according to the BMI-for-age and sex reference data (5–19 years) [54]. Subjects were excluded based on the following criteria: (1) self-report of muscle/TMJ pain, (2) history of previous orthodontic treatment, (3) presence of teeth decay and/or missing teeth, (4) dental origin, (5) periodontal pockets (>3 mm), (6) subjects classified as underweight, overweight and obesity, (7) presence of chronic diseases/conditions such as neurological or cognitive deficit, (8) previous or current tumors or traumas, (9) complains of xerostomia and (10) current use of analgesic, anti-inflammatory and psychiatric drugs.

2.3. Anthropometric evaluations

Anthropometric evaluation included the measurements of weight, height and body mass index (BMI = kg/m^2). In addition, the body skeletal muscle mass was measured using Bioelectric Impedance (InBody 230, Biospace Co. Ltd., Gangnan-gu, Seul, South Korea). The InBody 230 is a segmental impedance device, which uses a tetrapolar 8-point tactile electrode method. During impedance measurements, the participants were in a normal standing position with the arms and legs extended, in accordance with the manufacturer's instructions. The subjects removed their shoes and socks and wore light clothing. Moreover, the analyses were performed in the morning, without subjects having done exercise or eaten before this (at least 2 h after the last meal).

The facial anthropometry examination was performed using a sliding caliper (Bone Caliper in 240 mm aluminum, Cescorf, Brazil). For each volunteer, seven craniometric points were determined (Fig. 1), located by palpation/inspection and marked directly on the skin using an eyeliner. All subjects were seated in a relaxed position, with the Frankfort plane horizontal to the floor and teeth in the intercuspal position [14,23].

The distances: *nasion-gnathion*, *subnasale-gnathion*, *zigion-zigion* and *gonion-gonion* were evaluated in millimeters, considering the following landmarks: the *nasion* is the most anterior point of the fronto-nasal outline in the midline; *gnathion* is the most anterior and inferior point of the bony chin; *subnasale* is where the lower margin of the nasal septum is confluent with the intergumental upper lip; *zygion* is the most lateral point on the zygomatic arch; and *gonion* is the lowest posterior and outward point of the angle of the mandible.

2.4. Peer assessment rating (PAR) index

The assessment of the severity of malocclusion was performed using the Peer Assessment Rating (PAR) index, which was based on the sum