Respiratory Muscle Strength, Sound Pressure Level, and Vocal Acoustic Parameters and Waist Circumference of Children With Different Nutritional Status

*Fernanda dos Santos Pascotini, *Vanessa Veis Ribeiro, *Mara Keli Christmann, †Lidia Lis Tomasi, †Amanda Alves Dellazzana, *Leris Salete Bonfanti Haeffner, and *Carla Aparecida Cielo, *†*Santa Maria, Rio Grande do Sul, Brazil*

Summary: Objective. Relate respiratory muscle strength (RMS), sound pressure (SP) level, and vocal acoustic parameters to the abdominal circumference (AC) and nutritional status of children.

Study Design. This is a cross-sectional study.

Methods. Eighty-two school children aged between 8 and 10 years, grouped by nutritional states (eutrophic, overweight, or obese) and AC percentile (≤25, 25–75, and ≥75), were included in the study. Evaluations of maximal inspiratory pressure (IPmax) and maximal expiratory pressure (EPmax) were conducted using the manometer and SP and acoustic parameters through the *Multi-Dimensional Voice Program Advanced* (KayPENTAX, Montvale, New Jersey).

Results. There were significant differences ($P < 0.05$) in the EPmax of children with AC between the 25th and 75th percentiles (72.4) and those less than or equal to the 25th percentile (61.9) and in the SP of those greater than or equal to the 75th percentile (73.4) and less than or equal to the 25th percentile (66.6). The IPmax, EPmax, SP levels, and acoustic variables were not different in relation to the nutritional states of the children. There was a strong and positive correlation between the coefficient of amplitude perturbations (shimmer), the harmonics-to-noise ratio and the variation of the fundamental frequency, respectively, 0.79 and 0.71.

Conclusions. RMS and acoustic voice characteristics in children do not appear to be influenced by nutritional states, and respiratory pressure does not interfere with acoustic voice characteristics. However, localized fat, represented by the AC, alters the EPmax and the SP, each of which increases as the AC increases.

Key Words: Obesity–Breath–Muscle strength–Voice.

INTRODUCTION

Obesity is a chronic, multifactorial disease that results from weight gain due to higher consumption than energy expenditure.[1] It is currently considered one of the most serious public health problems.[2–6] It is known that childhood obesity has increased significantly and that it causes many complications in childhood and adulthood.[4,7]

Among these complications, the pulmonary ones stand out.[8,9] Obesity can affect the chest and diaphragm, thereby causing changes in respiratory functions even when the lungs are normal. This is due to an increase in respiratory effort and a compromised gas transportation system. Obesity can also lead to hypothonia of the abdominal muscles, which impairs the respiratory function that depends on the diaphragm, ultimately reducing the strength and resistance of respiratory muscles.[10]

The respiratory system is responsible for activating the voice, so any change in air function can have direct consequences on speech and voice (sound pressure [SP], height, and quality).[11–15]

Expiratory air is the basis of vocal production, as it is converted into sound by passing through the glottis. Thus, proper breathing is essential for healthy phonation or, in other words, for balanced levels of vocal production: breathing, phonation, and articulation or resonance.[15–19]

There are few scientific articles that portray the respiratory muscle strength (RMS) of obese children and there are no articles that identify their acoustic vocal features and the correlation between the two. Thus, the aim of the study was to relate the RMS, SP level, and vocal acoustic parameters to the abdominal circumference (AC) and nutritional states of children.

METHODS

A cross-sectional study, approved by the Research Ethics Committee (No. 245 208) and the Municipal Secretary of Education, was conducted between March and July of 2013 in a medium-sized city (270 000 inhabitants) in southern Brazil. A drawing was conducted among public schools, and an institution was selected. Elementary students of both sexes, whose parents read, agreed, and signed the informed consent form, were included. Initially, an interview with parents or guardians was performed and then a children's hearing was screened by scanning pure tones at frequencies of 500, 1000, 2000, and 4000 Hz, 15 and 25 dB, only through the airway (with Fonix FA-12 type I, Frye Electronics, INC, San Jose, California).

The exclusion criteria were malnutrition, stage 3 or higher of pubertal development; laryngeal diseases, chronic respiratory

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From the *Human Communication Disorders, Federal University of Santa Maria/UFSM, Santa Maria, Rio Grande do Sul, Brazil; and the †Federal University of Santa Maria/UFSM, Santa Maria, Rio Grande do Sul, Brazil.

Address correspondence and reprint requests to Fernanda dos Santos Pascotini, Federal University of Santa Maria/UFSM, Rua Nabuco de Araújo, n.41, apto 401—Bairro Perpétuo Socorro, Santa Maria, Rio Grande do Sul 97045-340, Brazil. E-mail: fepascotini@hotmail.com

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diseases, oral or nasal breathing, neurological or gastric diseases, and the presence of congenital postural changes reported by parents or guardians; any degree of hearing loss detected by audiometry; flu and/or respiratory conditions at the time of the evaluation; inability to perform evaluation techniques; and reported participation in choirs.

From a total of 115 students, 33 children were excluded: four for being in stage 3 of pubertal development, one for presenting a mild degree of hearing loss, two for having neurologic disorders, five for having the flu and/or respiratory diseases at the time of the assessment, 10 for having chronic respiratory conditions, six for being mouth breathers, two children because they did not have the ability to perform the evaluation techniques correctly, two for being participants in choirs, and seven for malnutrition. The sample, then, consisted of 82 students aged between 8 and 10 years (mean 9.2 ± 0.8 years), 78% being 9 or 10 years and 53.7% being female. The sample showed a confidence level of 99%, with a statistical power of 80%, relative risk of 2.0 for reasons of nonexposed/exposed to 2:1.

The variables were obtained through anthropometric measurements (weight and height), manometer (maximal inspiratory pressure [IPmax] and maximal expiratory pressure [EPmax]), and voice recording (acoustic parameters). Anthropometric measurements were collected by a physical therapist and performed in a standardized manner.[20] Body weight was measured using a Britain digital scale, of personal use, with a maximum capacity of 120 kg and a precision of 100 g. Height was measured using a Sanny (São Bernardo do Campo, Brazil) portable stadiometer, with a precision of 1 mm.

Body mass index (BMI) was calculated by dividing weight in kilograms by height in square meters and transformed into Z scores. The nutritional status of the children was established by the Z score of the BMI for age and sex, considered for ages 5–19 years and thus classified as eutrophic Z score >-2 and <1, overweight ≥ 1 and ≤ 2, and obese >2.

The AC was measured on the site between the last rib and the iliac crest, more precisely at the level of the umbilicus, using a Sanny tape measure. The individual was standing on a horizontal plane,[21] and the amount was verified in centimeters. The measures of AC were divided into percentiles, and after that, the children were classified into three groups: ≤ 25 (61 cm circumference), between 25 and 75 (between 61 cm and 75 cm), and ≥ 75 (larger than 75 cm).

The RMS, measured by maximal respiratory pressures (MRPs), was measured using a Global med MVD300 digital manometer (Globalmed, RS, Brazil), calibrated in cm H_2O. The child was maintained in a sitting position with a nose clip closing his/her nostrils and was asked to exhale (to residual volume) as much as possible and then, properly adjusting the lips to the mouthpiece to prevent air leakage, the child was instructed to inhale as much as possible, thereby obtaining the IPmax. To measure the EPmax, the subject was asked to inhale as much as possible (to total lung capacity) and then exhale as much as possible with his/her mouth attached to the nozzle. To minimize the use of the accessory muscles of the face, the examiner manually secured the child's cheeks. Two learning maneuvers were performed, and the child raised his/her hand to indicate when the lungs were inflated/deflated. Three measurements of IPmax and EPmax were performed, and the highest of the three was considered acceptable. As it was a stress-dependent test, the child was provided verbal encouragement to perform the task.[22]

The level of the SP was measured with a SP level meter, Instrutherm model Dec-480 (SP, Brazil), positioned on the side of the body (30 cm of the labial commissure of the individual), during the utterance of the vowel /a/, which was considered a modal value.[23]

For voice recording, each subject was asked to stand in an upright position. The recorder-coupled microphone (ZoomH4n [Japan], stereo, unidirectional microphone, 96 KHz, 16 bit, 50% of recording level from the input signal) was positioned at an angle of 90° from the mouth of the subject at a distance of 4 cm between the recorder and the mouth.[15,24,25] The sample voice for the acoustic analysis relied on the support of the vowel /a/, which was emitted with normal pitch and loudness and in the maximum phonation time of at least 3 seconds.[24]

The acoustic analysis was extracted using *Multi-Dimensional Voice Program Advanced* (KayPENTAX), and a 44-KHz and 16-bit sampling rate was used. From the program, the various acoustic measurements used in this study were extracted, which are as follows: fundamental frequency (f0); noise-to-harmonics ratio (NHR); the pitch perturbation quotient (PPQ); amplitude perturbation quotient (APQ); the voice turbulence index (VTI); soft phonation index (SPI); frequency range (vf0); and amplitude variation (vAm), which are described in literature as the most used in clinical speech therapy.[24,26]

The data were analyzed using *Stata* software 10 (Texas). After checking the normality of the variables, using the Shapiro-Wilk test, the means and standard deviations were calculated. To check for differences between groups, analysis of variance (ANOVA) and the Scheffe posttest were used. To calculate the correlation, the Pearson correlation test was used, and the following correlation values were used: ≥ 0.70 as strong, between 0.30 and 0.70 as moderate, and <0.30 as weak. The value $P < 0.05$ was considered a significant difference.

OUTCOMES

The participants in the study were 82 school children, aged between 8 and 10 years, with an average age of 9.2 ± 0.8 years, and 53.7% were female, 46.4% were eutrophic, 26.8% were overweight, and 26 8% were obese. There was no difference in the respiratory and vocal variables in relation to nutritional status, with the exception of the AC, which was as expected in obese children (79.7 cm), followed by those who were overweight and eutrophic (Table 1).

There was a significant difference between the EPmax percentile of children with an AC between 25 and 75 and ≤ 25 ($P = 0.047$), whereas the difference in the SP occurred among those in the ≥ 75 and ≤ 25 ($P = 0.003$) percentiles. A lower AC meant a lower average EPmax and SP. The other variables were similar in relation to the percentile rank in the AC (Table 2).