REVISTA CEFAC
SPEECH, LANGUAGE, HEARING SCIENCES AND EDUCATION JOURNAL
Rev. CEFAC. 2016 Jul-Ago; 18(4):915-922 doi: 10.1590/1982-0216201618419315

**Original articles**

# Forced vital capacity and maximum phonation time compared to waist circumference and nutritional status of children

## *Capacidade vital forçada e tempos máximos de fonação em relação à circunferência abdominal e ao estado nutricional de crianças*

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Conflict of interest: non-existent

**ABSTRACT**

**Purpose:** to evaluate and correlate forced vital capacity and maximum phonation time in relation to abdominal circumference and nutritional status of children.

**Methods:** cross-sectional study of 82 children aged between eight and ten years, divided by the nutritional status (eutrophic, overweight and obese) and the percentile of abdominal circumference (≤ 25, 25 the 75, ≥ 75). There was forced vital capacity by spirometry and maximum phonation time the /e/, /a/ and /e/ voiceless (/ė/).

**Results:** the forced vital capacity was higher in children with higher abdominal circumference ($p = 0.003$) and percentiles of abdominal circumference 25-75 had longer sustain the vowels ($p < 0.05$). No statistically significant difference in forced vital capacity and TMF /e,a,ė/ in relation to nutritional status. There was strong correlation between /a/ maximum phonation time and maximum phonation time /e/ (0.84).

**Conclusion:** the nutritional status of children did not influence the volume of expired air and measures of maximum phonation time, but it is perceived that a higher abdominal circumference, which is located fat, increases lung function.

**Keywords:** Obesity; Breathing; Voice

**RESUMO**

**Objetivo:** avaliar e correlacionar capacidade vital forçada e tempos máximos de fonação em relação à circunferência abdominal e ao estado nutricional de crianças.

**Métodos:** estudo transversal analítico com 82 crianças, entre oito e dez anos de idade, divididas pelo estado nutricional (eutrófica, sobrepeso e obesas) e pelo percentil da circunferência abdominal (≤25, 25 a 75 e ≥75). Verificou-se a capacidade vital forçada pela espirometria e os tempos máximos de fonação de /e/, /a/ e /e/ áfono (/ė/).

**Resultados:** a capacidade vital forçada foi maior nas crianças com maior circunferência abdominal ($p=0,003$) e as com percentis da circunferência abdominal de 25 a 75 tiveram maiores tempos máximos de fonação /e,a,ė/ ($p<0,05$). Não foi encontrada diferença estatística significante das variáveis capacidade vital forçada e tempos máximos de fonação/e,a,ė/ em relação ao estado nutricional. Existiu correlação forte entre tempo máximo de fonação /a/ e tempo máximo de fonação /e/ (0,84).

**Conclusão:** o estado nutricional das crianças não influenciou o volume de ar expirado e às medidas de tempos máximos de fonação, mas percebe-se que uma maior circunferência abdominal, que representa a gordura localizada, aumenta a função pulmonar.

**Descritores:** Obesidade; Respiração; Voz

Received on: November 17, 2015
Accepted on: January 11, 2016

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## INTRODUCTION

The air expiration acts as a source that activates phonation with a direct effect upon the voice[1-4], aerodynamic measures being used on the differential diagnosis of the breathing control along with laryngeal and vocal changes[5]. The forced vital capacity (FVC) evaluation is very used and its measure determines the amount of air that can be expired from the lungs after a maximum inspiration[6]. Maximum phonation time (MPT) evaluation refers to the maximum time an individual can stand an emission during the same expiration, demonstrating the effectiveness of the respiratory and laryngeal coordination[1,3,5-8].

A reduced FVC may hamper the emission sustention leading to a glottal hypertension in an attempt to maintain vocal production. Besides the FVC measure variability among the population groups, many variations on the MPT values[6,7] can also be observed.

Over the past decades overweight and obesity in scholars have increased at alarming levels, representing a serious public health issue[9,10]. On adult population there are some evidences that obesity may interfere on voice and respiratory function, however on the infant population few studies demonstrating changes on the respiratory system and zero studies on vocal alterations were found. Thus the aim of this study was to evaluate and correlate FVC and MPT in relation to abdominal circumference (AC) and children's nutritional status.

## METHODS

Cross-sectional study accomplished from March to July 2013, approved by the Comitê de Ética em Pesquisa of the Federal University of Santa Maria (parecer nº 245.208) and by the Secretaria Municipal de Educação of the medium sized city from the South of Brasil. A raffle among municipal schools was made, with an institution being selected children from the elementary school of both genders were included, then the children's parents or children's tutors read, agreed and signed the Termo de Consentimento Livre e Esclarecido (TCLE). Initially an interview with children's parents or children's tutors and hearing screening was made through a scan of pure tones on 500, 1000, 2000 and 4000Hz[4] frequencies, a 25dB, only through the airway (with Fonix audiometer, FA-12 model type I).

Malnutrition; stage 3 or superior of pubertal development; presence of laryngeal diseases; chronic respiratory diseases; oral or nasal breathing; gastrointestinal or neurological disorders and the presence of congenital postural alteration reported by the parents or children's tutors; any degree of hearing loss detected by the audiometric evaluation; the flu and/or respiratory diseases on the day of the evaluations; lack of ability on performing the evaluation techniques; report of choral participation, were the exclusion criteria.

From a total of one hundred fifteen (115) scholars thirty three (33) children were excluded: four due to being on stage three or superior of pubertal development, one for presenting a low degree of hearing loss, two for possessing neurological disorder, five for presenting the flu and/or respiratory diseases on the day of the evaluations, ten for being bearers of chronic respiratory diseases, six for being oral breathers, two children for not having the ability to perform the evaluation techniques correctly, two for being members of choral and seven due to malnutrition. Thus, the sample was composed by eighty two (82) scholars aged between eight and ten years ( 9,2 ± 0,8 years old average), 78% aged between nine and ten years and 53,7% from female gender. The sample presented trust level of 99%, with statistical power of 80%, relative risk of 2,0 to the reason of non-exposed/exposed in 2:1. The relative risk refers to the exposure towards the overweight of the scholars whose parameters in this study were the nutritional status and the abdominal circumference.

The studied variables were obtained through the anthropometric evaluation (weight and size), spirometry (FVC) and MPT measures /a/, /e/ and /ė/. Anthropometric measures were collected by a physiotherapist and performed in a standardized way[11]. The body weight was obtained using a digital scale of the *Britânia* brand, from personal use, with maximum capacity of 120 kg and 100g accuracy. The size was measured using a portable stadiometer of the *Sanny* brand with millimeter accuracy.

The body mass index (BMI) was calculated by dividing the weight in kilogram through the size in square meters transformed in Z-score. The scholars nutritional status was established by the BMI Z-score to age and gender, considered for ages from five to nineteen years old and so classified: eutrophic Z-score >-2 and <+1, overweight ≥+1e ≤+2 and obese >+2[12].

The abdominal circumference (AC) was measured among the last rib and the iliac crest, more precisely on umbilical scar level, in a horizontal plane with the individual standing, using a *Sanny*® brand tape measure, with millimeter accuracy[13] and the value being verified in centimeters. AC measurements were distributed in percentile and after children were classified in three groups: ≤25 (when the circumference reached up to 61 cm), between 25 and 75 (when it was between 61 and 75 cm) and ≥75 (when it was larger than 75 cm).

The spirometry was performed through portable spirometer of *MIR* (Spirobank II Model, USA) brand. The children stood in sitting position using a nose clip and were advised to execute a maximal inspiration followed by a quick and sustained expiration on the equipment opening until the observer commanded the interruption. The forced expiration duration should be of six seconds, at least. The individual was strongly encouraged that the effort was "explosive" at the beginning of the procedure. Three acceptable and reproducible procedures were performed with the major value being selected for the analysis[14].

In order to collect the MPT children were positioned standing with their arms along their bodies. For the utterance of the /a/ and /e/ phonemes, they were advised to make sustained emissions, after a deep inspiration, in *loudness*, *pitch,* quality and speed common on speech[15]. For the utterance of /ė/, they were advised to emit the /e/ in a voiceless and extended way without noise or vocalization, keeping the articulatory posture of the utterance of the /e/ vowel closed[7]. Each child performed three sustenance of each MPT up to the end of the expiration, with a pause of 10 seconds among each one, timing every emission in seconds and only the highest value out of three measures was considered[4,15].

For data analysis the normality of the variables was verified through the *Shapiro-Wilk* test and as the variables did not present a normal distribution the median and the 1st and 3rd quartiles were calculated. In order to verify the difference among the groups the *Kruskall-Wallis* test and the *Wilcoxon* test were used. The correlation test by *Pearson* was also used, considering strong correlation value ≥0,70, medium between 0,30 up to 0,70 and weak <0,30. A statistical significant difference was considered p<0,05. The data were analyzed by the STATA 10 *software*.

## RESULTS

Demographic characteristics of the eighty two (82) children who made part of the sample are aged 9,2(±0,8) years on average, 53,7% being of the female gender and 53,6% overweight (Table 1).

**Table 1.** Demographic characteristics and nutritional status of the sample

| Variables | n | % |
|---|---|---|
| **Gender** | | |
| Male | 38 | 46,3 |
| Female | 44 | 53,7 |
| **Age (years)** | | |
| Eight | 18 | 22,0 |
| Nine | 33 | 40,2 |
| Tem | 31 | 37,8 |
| **Nutritional Status** | | |
| Eutrophic | 38 | 46,4 |
| Overweight | 22 | 26,8 |
| Obese | 22 | 26,8 |

Subtitle: n: number of subjects; %: percentage of subjects in relation to the sample's total.

FVC's median increased according to the AC percentile classification with biggest value on children with AC ≥75. In relation to the MPT the highest median value of /e/ and /a/ occurred on participants with AC percentile among 25 and 75, with statistical difference (Table 2).

On AC median there was a significant difference among the nutritional statuses being higher on obese children followed by overweight and eutrophic children, respectively. FVC and MPT variables had similar values on three nutritional statuses, with no statistically significant difference (Table 3).

On table 4 one can observe a strong and positive correlation (0,84) among MPT /a/ and MPT /e/, moderate positive correlation among AC and FVC (0,42) and moderate negative correlation among MPT /è/ and AC (-0,23).

**Table 2.** Forced vital capacity and maximum phonation time's median according to the percentile classification of abdominal circumference from evaluated children

| Variables | Abdominal Circumference Percentile | | | p* |
|---|---|---|---|---|
| | ≤ 25<br>md (1º/3ºq) | >25 e <75<br>md (1º/3ºq) | ≥75<br>md(1º/3ºq) | |
| FVC (l) | 1,92 (1,71-2,16)[a,b] | 2.23 (1.9-2.5)[a] | 2.38 (2,12-2,57)[b] | 0,003* |
| MPT/e/ (s) | 10,23 (8,83-12,31) | 12.64(8,3-16,1)[a] | 8.78 (7,56-10,44)[a] | 0,049* |
| MPT/a/ (s) | 8,79(7,47-11,64)[a] | 11.51(8,9-16,0)[a,b] | 9,51(8,47-11,11)[b] | 0,007* |
| MPT/ė/ (s) | 8,85 (6,30-12,0) | 7,59 (5,7-10,9) | 6,30 (4,93-8.00) | 0,101 |

Subtitle: *= Kruskal Wallis test (p<0,05); [a,b]= Wilcoxon test (p<0,05); md: median; (1º/3ºq): First/Third quartile; FVC: Forced Vital Capacity; MPT: maximum phonation time; s: seconds; l: liters

**Table 3.** Abdominal circumference median, forced vital capacity and maximum phonation time according to children's nutritional status

| Variables | Nutritional Status | | | p* |
|---|---|---|---|---|
| | Eutrophic<br>md (1º/3ºq) | Overweight<br>md (1º/3ºq) | Obese<br>md (1º/3ºq) | |
| AC (cm) | 60 (57-64)[a] | 69 (65-74)[a,b] | 82 (72-85)[a,b] | <0,001* |
| FVC (l) | 2,02 (1.79-2.35) | 2.18 (1.96-2.45) | 2.33 (1.94-2.6) | 0,124 |
| MPT/e/ (s) | 10,23 (8,83-12,31) | 12.64(8,35-16,1) | 8.78 (7,56-10,44) | 0,692 |
| MPT/a/ (s) | 10.23(7,54-12,8) | 11.17(9,07-16,84) | 10.29(8,36-13,8) | 0,172 |
| MPT/ė/ (s) | 7.73 (5,79-11.32) | 6.73 (5,1-9.98) | 7.52 (5,22-8.06) | 0,145 |

Subtitle: *= Kruskal Wallis test; [a,b]= Wilcoxon test (p<0,05); md: median; (1º/3ºq): First/Third quartile; AC: abdominal circumference; FVC: Forced Vital Capacity; MPT: maximum phonation time; cm: centimeters; l: liters; s: seconds

**Table 4.** Correlation among abdominal circumference variables, forced vital capacity and maximum phonation time

| Variables | AC | FVC | MPT/e/ | MPT/a/ | MPT/ė/ |
|---|---|---|---|---|---|
| AC | - | | | | |
| FVC | 0,42[a] | - | | | |
| MPT/e/ | -0,07 | 0,03 | - | | |
| MPT/a/ | -0,03 | 0,04 | 0,84[a] | - | |
| MPT/ė/ | -0,23[b] | 0,07 | 0,11 | 0,15 | - |

Pearson's Correlation Test; [a]: p<0,001; [b]: p=0,034;
Subtitle: AC: abdominal circumference; FVC: forced vital capacity; MPT: maximum phonation time

## DISCUSSION

Over the past few years overweight and obesity in scholars has increased at alarming levels[9] and its acquiring great significance on the health field especially due to the impact that it has on children's lives, bringing physical, economic and psychological consequences. Besides, the probability of obese children to remain the same way in adult life is three times higher than eutrophic children[16]. Several studies call the attention to the increasing elevation of obesity predominance on worldwide population, including children, in accordance with what was also confirmed in the present study, highlighting a serious public health issue[9,16].

FVC that is the amount of air that can be expired from the lungs after a maximum inspiration[6-8], has showed itself higher on children with more AC. Nevertheless, studies in adults demonstrate that the fat deposit's location influences the ventilation function alterations, such abnormalities being more common on central obesity, where the accumulation of adipose tissue is located on the waist region and has probably a mechanical effect right through the ribcage and the diaphragm restraining the lung expansion causing the reduction of lung volumes[17,18].

The association between lung dysfunction and overweight has been demonstrated by the reduction of FVC and other lung volumes. The compliance decrease of the thoracic wall or its inactivity, besides the expiratory reserve volume reduction, related to the abdominal fat accumulation and above the rib cage plus the increase on the endurance of the respiratory tract are aspects that can explain the fact[17-19].

The FVC and MPT presented similar values on the three nutritional statuses. Such results are compatibles with the ones observed in a study with one hundred fifty six (156) asymptomatic volunteers thirty two (32) being eutrophics, thirty nine (39) overweight and eighty five (85) obese which did not detect correlation between obesity and FVC[20] also another study made with forty six college students aged between 20 and 40 years did not demonstrate changes on FVC and lung volumes in obese people classified by the MBI[21]. A research with one hundred sixty two (162) children aged between 8 and 11 years demonstrated that moderate childhood obesity does not interfere on the ventilatory functional capacity[22]. A literature review state that obesity stages I and II does not cause a FVC significant commitment[23].

Other researchers reported that the obese individuals' pulmonary function test may be within normal standards, except in morbid obesity cases[17,24]. Obesity stage III (severe) was established as one that may alter spirometric values due to the diaphragmatic dynamic commitment as well as the chest wall's musculature. At the same time on individuals with obesity stages I and II (light-to-moderate) such changes are much changeable and need specific evaluation[23]. The children analyzed in this study had obesity stage I light-to-moderate which may explain the fact that the significant difference on lung function was not found on them.

Despite the lung volumes remain within the normal range on light-to-moderate obesity, some former studies report that in obese individuals the weight loss leads to improvement on lung volumes[24,25]. Such data suggest the possibility of a progressive adaptation of the respiratory system compared to the long term weight gain – more than a year, as the study suggests[26].

Therefore it is possible to suggest that due to presenting long term obesity, obese individuals have developed adaptive mechanisms against the overburden imposed by adipose tissue along with the muscular work increase hence do not present important decrease on spirometric values[21,27]. This possibility is reinforced by the present study found about the significant FVC rise as the AC rise. It seems like on young individuals BMI increase can be associated with the pulmonary function due to muscular effect. Initially an increase of the pulmonary function with weight gain occurs because of the muscular strength growth, however, secondarily, a reduction on the pulmonary function occurs due to the modality commitment of the rib cage[28].

Although the respiratory function alterations are common in obese adults, one cannot generalize its results to the child population, once their physiological function and body fat deposition are different. Moreover, there are many risk factors such as smoking, abnormal values on the pulmonary functions' test by pulmonary intrinsic disease or by other factors beyond obesity[29].

There is a shortage on current studies that evaluate the pulmonary function on overweight children. The evaluation of one hundred thirty (130) children aged 9,7 (±2,5) years old on average, eighty (80) being overweight and fifty (50) eutrophic, has shown similar values to the pulmonary functions including FVC for both groups[28]. Likewise, the pulmonary function evaluation of thirty (30) individuals aged between 6 and 14 years, pointed that FVC and $FEV_1$ parameters were similar on both obese and eutrophic individuals[30].

On the contrary, a research which performed pulmonary function test on one hundred twenty two (122) individuals aged between 7 and 14 years, from both genders, has shown that weight has a significant effect upon the pulmonary function values on young people, with the initial increase of the pulmonary function through the muscular effect and then, the decrease through obesity's effect[31]. Another study results[32] has also shown gradual increase on FVC values related to a BMI increase. This also supports the present study found on the significant FVC increase as AC increases. Nevertheless the respiratory function data on obesity is still very controversial. According to some of the authors[28,31], a possible explanation for such discrepancy may be the fact that most studies concerns extreme obesity levels or have a small sample size, with no control group.

Breathing has an indispensable role on phonation, since the sufficient and sustained air pressure depends on it, in order to obtain a good benefit from the expired air, converting it into a glottal sound and keeping the right dynamic among the vocal production sublevels; respiratory, phonation and resonant/articulatory[1,4,5]. The MPT is an objective test widely used in clinical evaluation of speech and voice, which provides information about the respiratory support and the glottal efficiency, besides the aerodynamic and neuromuscular control on the vocal production of an individual[2]. Thus, a sustained emission may indicate and quantify the relation of the muscular action and mucosal waves of the vocal folds and the lungs' air flow, reflecting on physical and functional conditions[15].

The /a/ and /e/ vowels are more open and central and detect minimum changes in glottal level[3]. The voiceless phonation of /e/ (/ė/) differs from the previous because it does not require vocal folds vibration and is more reliable on the evaluation of the control by exclusive respiratory support[1,7]. In relation to MPT /e,a/ children with AC percentile between 25 and 75 had a significant higher MPT in relation to others, possibly justified by the literature under the weight gain influence on the FVC previously mentioned, which may have an influence on these emissions[23,24,27,30,31]. However, there was no significant statistic difference according to the nutritional status, showing that it does not seem to affect the pneumo-phonatory coordination, which was not found on literary researches for comparison.

A weak and negative correlation was observed between MPT /ė/ and AC, that is, as the AC increased /ė/ sustenance decreased, reinforcing the found that MPT /ė/ was higher on eutrophics, even without statistical significance among sustained groups. The FVC and MPT did not present correlation on studied children. In this sense, studies which evaluate this relation with obese children were not found, only few in adults which found a positive relation among the variables[3,7]. It is possible that, in childhood, obesity still does not influence MPT.

The design of this study, which is the transverse type, can be one of its own limitations, since it's hardly possible to complete a cause and effect relation. Nevertheless, the observed results reinforce that changes on the ribcage from childhood obesity might have future consequences on the respiratory and vocal functioning as well as in other stages of life.

## CONCLUSION

The evidences found in this study suggest that the nutritional status in children aged between eight and ten years did not influenced their pulmonary function, in what regards forced vital capacity, as well as the efficiency of the laryngeal and respiratory coordination regarding maximum phonation time. On the other hand the increase on the abdominal circumference that represents located fat may interfere on lung and phonation function, increasing forced vital capacity and decreasing MPT /ė/ sustention. Along with this study new paths are open for future researches aiming at deepen the presented topic, once that obesity on the studied age still did not bring negative consequences to lung and vocal function, but it may arise on adult life.

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