

# FREQUÊNCIA FUNDAMENTAL, TEMPO MÁXIMO DE FONAÇÃO E QUEIXAS VOCAIS EM MULHERES COM OBESIDADE MÓRBIDA

*Fundamental frequency, phonation maximum time and vocal complaints in morbidly obese women*

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**ABSTRACT - Background:** Obese people have abnormal deposition of fat in the vocal tract that can interfere with the acoustic voice. **Aim:** To relate the fundamental frequency, the maximum phonation time and voice complaints from a group of morbidly obese women. **Methods:** Observational, cross-sectional and descriptive study that included 44 morbidly obese women, mean age of 42.45 ( $\pm 10.31$ ) years old, observational group and 30 women without obesity, control group, with 33.79 ( $\pm 4.51$ ) years old. The voice recording was done in a quiet environment, on a laptop using the program ANAGRAF acoustic analysis of speech sounds. To extract the values of fundamental frequency the subjects were asked to produce vowel [a] at usual intensity for a period in average of three seconds. After the voice recording, participants were prompted to produce sustained vowel [a], [i] and [u] at usual intensity and height, using a stopwatch to measure the time that each participant could hold each vowel. **Results:** The majority, 31(70.5%), had vocal complaints, with a higher percentage for complaints of vocal fatigue 20(64.51%) and voice failures 19(61.29%) followed by dryness of the throat in 15 (48.38%) and effort to speak 13(41.93%). There was no statistically significant difference regarding the mean fundamental frequency of the voice in both groups, but there was significance between the two groups regarding maximum phonation. **Conclusion:** Increased adipose tissue in the vocal tract interfered in the vocal parameters.

**HEADINGS** - Obesity, morbid. Voice. Adipose tissue. Bariatric surgery

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**RESUMO - Racional:** Sujeitos obesos apresentam deposição anormal de gordura no trato vocal que podem interferir nos parâmetros acústicos da voz e consequente queixa vocal. **Objetivo:** Verificar a frequência fundamental, o tempo máximo de fonação e as queixas vocais de mulheres com obesidade mórbida. **Métodos:** Estudo observacional, transversal e descritivo. Participaram 44 mulheres com obesidade mórbida, idade média de 42,45 ( $\pm 10,31$ ) anos de idade como grupo estudo e 30 mulheres sem obesidade, grupo controle, com média de 33,79 ( $\pm 4,51$ ) anos de idade. A gravação da voz foi realizada em ambiente silencioso, em laptop utilizando o programa ANAGRAF de análise acústica dos sons da fala. Para extrair os valores de frequência fundamental foi solicitado a emissão da vogal /a/ em intensidade e altura habituais, por um período em média de três segundos. Após a gravação da voz, foi solicitado a produção sustentada das vogais [a], [i] e [u] em intensidade e altura habituais, utilizando-se de cronômetro para mensurar o tempo que cada participante podia sustentar cada vogal. **Resultados:** As mulheres com obesidade mórbida, na sua maioria 31(70,5%) apresentaram queixa vocal, com percentual maior para as queixas de cansaço ao falar 20(64,51%) e falhas na voz 19(61,29%) seguidos de ressecamento na garganta 15(48,38%) e esforço ao falar 13(41,93%). Não houve diferença estatisticamente significativa da média da frequência fundamental da voz em ambos os grupos; no entanto houve diferença significativa na média do tempo máximo de fonação entre os dois grupos. **Conclusão:** O aumento de tecido adiposo no trato vocal interferiu nos parâmetros vocais do grupo analisado.

**DESCRITORES** - Obesidade mórbida. Voz. Tecido adiposo. Cirurgia bariátrica.

## INTRODUCTION

Balanced voice is characterized by several factors ranging from anatomy and physiology of laryngeal structures to vocal tract adjustments used during voice production. The imbalance of these factors can generate different vocal characteristics. Among them, fundamental frequency is one of the major acoustic components of the voice and is determined by the vibration of the vocal folds, which act as a source for the production of sound and information about the physical attributes of the speaker. Such attributes include gender, age, state of mind, hormonal competence and body size of the speaker<sup>10,11,12</sup>.

The correlation between body shape and fundamental frequency seems plausible in some cases, considering the larynx is the hormonal target<sup>4,5,6,7,8,9,10,11,12,13,14,15,16,17,18</sup>. However, studies show that weight and body shape of male and female adults are negatively correlated with fundamental frequency<sup>7</sup>.

It is widely accepted that obesity is a growing issue in developed countries and, increasingly, in developing countries<sup>2</sup>. Authors<sup>16</sup> describe that obese people show abnormal fat deposition in the uvula, soft palate, lateral and posterior pharyngeal walls, and posterior part of the tongue, structures that belong to the vocal tract. Due to abnormal fat deposition in the upper airway, there is an increased thickening of the lateral walls of the pharynx, tongue size and soft palate length.

Authors<sup>1</sup> report that, due to the fat accumulated in the rhinopharyngeal, oropharyngeal and larynx regions, a geometric narrowing of the upper airway happens (extrathoracic trachea, larynx, pharynx and nose). This change causes a reduction in the functioning and sensitivity of respiratory chemoreceptors, which is offset by the hyperactivity of pharyngeal dilator muscles. This is due to the increase in type II muscle fibers in the upper airway dilator muscles and results in high capacity to generate tension<sup>6,7,8,9,10,11,12,13,14,15,16</sup>.

Authors<sup>8</sup> concluded in their studies on morbidly obese patients that, although the patterns of adiposity have not affected inspiratory muscle strength, neck adiposity was related to lower respiratory muscle strength. Moreover, neck adiposity also seems to hinder the airflow.

The respiratory support also impacts the measurement of maximum phonation time (MPT). This evaluation is used in speech therapy clinics to check vocal efficiency and allows for qualitative and quantitative observation of sound. It is an indirect and reliable measure that enables the evaluation of a patient's ability to control aerodynamic forces of the lung and myoelastic forces of the larynx<sup>13</sup>.

Studies were conducted<sup>11</sup> with 25 subjects of each gender and determined that maximum

phonation times below 10 seconds are considered pathologic. They also suggest that this is due to the glottal control or ineffective respiratory functioning.

Given this reasoning, it was proposed the following research questions, which this study aims: 1) could the accumulation of adipose tissue as a result of morbid obesity cause acoustic variations in the voice of these subjects, as there is a change in the space of the vocal tract?; 2) could the offset effort of upper or lower regions in relation to increased tissue regions – such as the laryngopharyngeal region – cause changes no MPT?

Considering these assumptions, the objective of this study is to correlate fundamental frequency, maximum phonation time and vocal complaints in morbidly obese and non-obese women.

## METHOD

This study was approved by the Ethics and Human Research Committee of the institution, Protocol No 207.630/2013. It is an observational, cross-sectional and descriptive study conducted with patients referred to bariatric surgery at a university hospital. Was studied 44 morbidly obese women with a mean age of 42.45 ( $\pm 10.31$ ), the obese group (OG), and 30 non-obese women with a mean age of 33.79 ( $\pm 4.51$ ), the control group (CG). The data to make the results of the control group were obtained from a database of a previous study. The exclusion criteria for the control group included: smoking, vocal complaints, having been intubated, thyroid issues, hormone replacement therapy, virus disease and allergy at the time of recording. The morbidly obese patients were informed about the study and could volunteer to participate. All of them were selected according to the following inclusion criteria: body mass index higher than 35 kg/m<sup>2</sup>; not on hormone replacement therapy and/or drug treatment; not smoking; not having been intubated; and not having thyroid issues, such as hyperthyroidism or hypothyroidism. These criteria were adopted so that no secondary factor to obesity affected the vocal quality of participants. Along with the consent form, participants also received a note of clarification to formalize their understanding and authorization to participate in this study. Then, an identification form was filled in with volunteers age, inclusion criteria data and information on vocal complaints - hoarseness, loss of voice, vocal fatigue, shortness of breath, globus sensation, burning or sore throat, dry throat, voice failure, effort to speak, and need to clear throat. These questions were prepared in order to characterize the group. The voice recording was done in a quiet room, on a laptop with a built-in external unidirectional microphone, and using the

ANAGRAF program for acoustic analysis of speech sounds<sup>9</sup> considering sample range of 22050. For voice collection, each patient sat with the microphone at a 5 cm distance from their mouth. To extract the values of fundamental frequency, patients were asked to produce vowel [a] at usual intensity and frequency, for three seconds on average. For the analysis, were excluded the beginning and the end of the emission because of their irregular characteristics, which occur due to phonation instability. After voice recording, participants were asked to produce sustained vowels [a], [i] and [u] at usual intensity and frequency, using a Stopwatch Vitesse timer to measure the time they could hold each vowel.

The statistical analysis was performed using PSPP software. The descriptive analysis included both absolute frequency and relative frequency, in addition to measures of central tendency (mean) and dispersion (standard deviation). To investigate the relation between qualitative variables we used Fisher's exact test and Chi-square test, and for the analysis of dependent and independent variables we used the non-parametric Mann-Whitney test, with a significance level of 5%.

## RESULTS

The OG sample included subjects aged 28-68 years (mean age 41.95) and the CG sample aged 26-44 years (mean age 33.79) (Table 1). The majority of the OG subjects 31(70.5%) reported vocal complaint with higher percentage in vocal fatigue 20(64.51%) and voice failure 19(61.29%), followed by dry throat 15(48.38%) and effort to speak 13(41.93%). Noteworthy, each patient was allowed to report more than one vocal complaint.

**TABLE 1** – Mean and standard deviation by age group, amount and percentage of vocal complaints reported by both groups

| Variables       | OG (n)44      | CG (n)30      |
|-----------------|---------------|---------------|
| Age group       | 41,95 (±10,0) | 33,79 (±4,51) |
| Vocal complaint |               | ---           |
| Yes             | 31 (70,5%)    | ---           |
| Vocal fatigue   | 20 (64,51%)   | ---           |
| Voice failure   | 19 (61,29%)   | ---           |
| Dry throat      | 15 (48,38%)   | ---           |
| Effort to speak | 13 (41,93%)   | ---           |
| No              | 13 (29,5%)    | 30 (100%)     |

Table 2 shows the results of the acoustic analysis of the fundamental frequency and MPT. Results show high significance, thus impacting the OG.

**TABLE 2** – Mean of fundamental frequency variables and MPT of vowels, maximum and minimum values and respective p values

|                            | N  | Mean           | Minimum and maximum values | p      |
|----------------------------|----|----------------|----------------------------|--------|
| Fundamental frequency      |    |                |                            |        |
| (OG)                       | 44 | 196,48(±35,52) | 94 - 265                   | 0,891  |
| (CG)                       | 30 | 204,00(±18,53) | 167-244                    |        |
| MPT of sustained vowel [a] |    |                |                            |        |
| (OG)                       | 44 | 9,16(±2,18)    | 4 - 15                     | 0,026* |
| (CG)                       |    |                |                            |        |
| MPT of sustained vowel [i] |    |                |                            |        |
| (OG)                       | 44 | 9,89(±3,12)    | 4 - 17                     | 0,048* |
| (CG)                       |    |                |                            |        |
| MPT of sustained vowel [u] |    |                |                            |        |
| (OG)                       | 44 | 9,39(±3,15)    | 4 - 18                     | 0,008* |
| (CG)                       |    |                |                            |        |

p<0.005\*- Non-parametric Mann-Whitney test (fundamental frequency) and Chi-square test (MPT)

**TABLE 3** – Mean of MPT for each vowel in the OG, maximum and minimum values and respective p values

|                            | N  | Mean        | Minimum and maximum values | p      |
|----------------------------|----|-------------|----------------------------|--------|
| MPT of sustained vowel [a] | 44 | 9,16(±2,18) | 4 - 15                     | 0,008* |
| MPT of sustained vowel [i] | 44 | 9,89(±3,12) | 4 - 17                     | 0,546  |
| MPT of sustained vowel [u] | 44 | 9,39(±3,15) | 4 - 18                     | 0,327  |

p<0.005\* - Fisher's exact test; MPT= maximum phonation time

## DISCUSSION

It is widely accepted that obesity is a public health issue worldwide.

The study group totaled 74 subjects, 44 morbidly obese women (OG), the observational group, and 30 non-obese women (CG), the control group. As shown in Table 1, the OG had a high percentage of vocal complaints. These data can be explained based on authors<sup>6,7,8,9,10,11,12,13,14,15,16</sup> mentioning that obese subjects show increased type II muscle fibers in the airway dilator muscles, which results in high capacity to generate tension. Fat accumulation in the neck seems to hinder the airflow, making it difficult to coordinate breathing and phonation, leading to vocal effort and, consequently, vocal complaints.

Although the mean of fundamental frequency is lower in the OG than in the CG, this difference was not statistically significant (Table 2) and shows that obesity in this group did not affect the values of this variable, in line with studies conducted by authors<sup>7</sup> demonstrating that weight and body size of male and female adults were negatively correlated with the fundamental frequency. They add that this fact can be explained by the growth of the human larynx, which does not depend on body size.

The mean of fundamental frequency in the OG found in this study (196.48±35.52), although considered low for a female standard, is close to

values found in other studies conducted with obese subjects<sup>4-6</sup> 192,18 Hz and 188 Hz, respectively. These results are consistent with arguments presented by authors<sup>1</sup> reporting that the increase of adipose tissue in the vocal tract of these subjects favors the reduction in the functioning and sensitivity of respiratory chemoreceptors, and consequently, the hyperactivity of the pharyngeal dilator muscles, which leads to the conclusion that increased tension of the extrinsic muscles of the larynx, secondarily responsible for voice frequency, may have been responsible for the reduction of fundamental frequency.

Maximum phonation time is achieved due to three physiological factors: total air capacity available for voice production, expiratory force and adjust of the larynx for efficiency in air usage, i.e., glottal resistance<sup>18</sup>.

In this study, the MPT was statistically significant between the two groups in all three sustained vowels. This result may be explained by neck adiposity in obese subjects associated with reduced respiratory muscle endurance<sup>9</sup>. Moreover, fat accumulation in the neck seems to hinder the airflow in obese subjects, who have difficulty performing respiratory movements in the same amplitude as non-obese subjects, which explains the imbalance between myoelastic and laryngeal aerodynamic forces and results in reduced MPT<sup>7</sup>.

Therefore, it was observed that OG subjects showed very low MPT values, in line with results from other studies<sup>5,6,7</sup>. Participating in the CG, despite showing a reduced mean of this variable comparing to literature<sup>3</sup>, reported MPT higher than 10 seconds, which was not found in the morbidly obese subjects (OG). It is important to highlight the studies that aimed to evaluate MPT in non-obese subjects and found results below the established standards<sup>14</sup>.

When comparing the mean values of MPT for the three vowels in the OG, there was statistically significant difference between vowel [a] and vowels [i] and [u]. This result may be explained by motor adjustments of the vocal tract during the production of vowel [a]. It is a low vowel, with no support from tongue and lips, as happens in the articulation of vowels [i] and [u] respectively, which may have happened due to the reduction in the functioning and sensitivity of chemoreceptors, offset by hyperactivity of the pharyngeal dilator muscle<sup>1</sup>, thus reducing the time to sustain this vowel.

This study sought to collaborate with the literature and provided preliminary results on objective measurements of voice and vocal complaints reported by morbidly obese women. The authors suggest the vocal assessment and speech therapy of these patients take into account the impact of morbid obesity on the voice.

## CONCLUSION

Morbidly obese women showed reduced maximum phonation time, with reduced sustained vowel [a], and mean of fundamental frequency low for female standard. Major vocal complaints were vocal fatigue and voice failure. Increased adipose tissue in the vocal tract affected the vocal parameters of the group studied.

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