

Increased body mass index: what is the influence on ventilatory muscular strength?

Índice de massa corporal aumentada: qual a influência sobre a força muscular ventilatória?

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ABSTRACT

Introduction: Ventilatory muscle strength (VMS) and anatomical / biological factors are important in the functioning and maintenance of body homeostasis. Thus, the study of respiratory mechanics and conditions that can alter them is fundamental. Studies indicate that obesity decreases the Maximum Inspiratory Pressure (MIP) and Maximum Expiratory Pressure (MEP), however, these studies are contradictory in their results. **Objective:** To verify if there is a difference between the VMS of obese and eutrophic individuals. **Methods:** Comparative observational study, in which 40 individuals of both sexes were evaluated, divided into two groups: 20 individuals with grade I obesity and 20 eutrophic individuals. Abdominal circumference was considered to be greater than 102 cm for men and 88 cm for women. Two-way unpaired Student's t-test was applied to compare the Maximum Inspiratory Pressure (MIP) and Maximum Expiratory Pressure (MEP) of the evaluated groups. The BioEstat 5.0 program was used and a $p < 0.05$ was adopted as significant. **Results:** The mean MIP for obese and eutrophic individuals was 147 ± 73 vs 145 ± 70 cmH₂O, respectively ($p = 0.91$). For MEP, the mean for the obese and eutrophic group was 133 ± 28 vs 135 ± 27 cmH₂O, respectively ($p = 0.93$). **Conclusion:** Sedentary individuals with grade I obesity associated with increased waist circumference do not differ in MIP and MEP when compared to eutrophic individuals.

Key-words: Obesity, Work Capacity Assessment, Functional Physical Performance.

RESUMO

Introdução: A força muscular ventilatória (FMV) e fatores anatômico/biológicos são importantes no funcionamento e manutenção da homeostasia corporal. Dessa maneira, é fundamental o estudo da mecânica respiratória e condições que podem alterá-las. Estudos apontam que a obesidade diminui a Pressão Inspiratória Máxima (PI_{máx}) e Expiratória Máxima (PE_{máx}), no entanto, esses estudos são contraditórios em seus resultados. **Objetivo:** Verificar se existe diferença entre a FMV de indivíduos obesos e eutróficos. **Métodos:** Estudo observacional comparativo, no qual foram avaliados 40 indivíduos de ambos os sexos, divididos em dois grupos: 20 indivíduos com obesidade grau I e 20 indivíduos eutróficos. Foi considerada aumentada a circunferência abdominal (CA) acima de 102cm para homens e 88cm para mulheres. Aplicado o teste t de Student não pareado bidirecional para comparação entre a Pressão Inspiratória Máxima (PI_{máx}) e Pressão Expiratória Máxima (PE_{máx}) dos grupos avaliados. Utilizado o programa BioEstat 5.0 e adotado como significativo um $p < 0,05$. **Resultados:** A média da PI_{máx} para obesos e eutróficos foi respectivamente de 147 ± 73 vs 145 ± 70 cmH₂O ($p = 0,91$). Para a PE_{máx}, a média do grupo obeso e eutrófico foram respectivamente de 133 ± 28 vs 135 ± 27 cmH₂O ($p = 0,93$). **Conclusão:** Indivíduos sedentários com obesidade grau I associado a aumento da circunferência abdominal não apresentam diferença na PI_{máx} e PE_{máx} quando comparados a indivíduos eutróficos.

Palavras-chave: Obesidade, Avaliação da Capacidade de Trabalho, Desempenho Físico Funcional.

Received on: November 26, 2020; Accepted on: December 15, 2020.

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Introduction

Obesity can bring changes in ventilatory muscle strength (VMS), caused by the accumulation of fat in the ribs, diaphragm, and abdomen, reducing the compliance of the rib cage and decreasing the diaphragmatic excursion [1].

The most used method to measure VMS is manovacuometry, which is frequently performed in clinical practice. In this test, two are the main determinants of VMS: the maximum inspiratory pressure (MIP) and the maximum expiratory pressure (MEP). MIP evaluates the strength of inspiratory muscles, while MEP evaluates the strength of expiratory muscles [2].

There are divergences in the scientific literature between studies on the reduction of VMS in obese individuals [3]. Carvalho *et al.* [4], a study with obese people and obstructive sleep apnea syndrome found that lung function, MIP, and capacity physical activity were reduced in obese individuals compared to eutrophic individuals. In the study conducted by Magnani and Cataneo [5], they found that obesity did not decrease VMS (MIP and MEP). Eli *et al.* [3], in a study comparing the VMS of morbidly obese with eutrophic women, obtained a surprising result: the studied morbidly obese women had a higher MIP than eutrophic women.

The discrepancies found in the literature point to the need for further studies to better clarify the VMS / body fat mass ratio. These counterpoints can be explained by biases such as the unmatched groups and the non-isolation of the buccinator muscle when measuring MIP and MEP. Therefore, given the above, the present study aimed to test the hypothesis that VMS is different between obese and eutrophic individuals and to verify whether there is a correlation between BMI and abdominal circumference (AC) with MIP and MEP.

Methods

Analytical cross-sectional study, in which 40 individuals of both sexes were evaluated, divided into two groups (14 men in each): 20 individuals with grade I obesity and 20 eutrophic individuals. To compose the groups, it was adopted as inclusion criterion AC greater than 102cm for men and greater than 88cm for women in the type I obesity group, and, necessarily in the eutrophic group, the abdominal circumference was within the limits considered normal. Only sedentary or irregularly active individuals are included, according to the international physical activity questionnaire - long version [6].

Height was measured with the aid of a professional Sanny® stadiometer (Brazil) with an accuracy of 0.1cm, performed with the subjects barefoot and with the buttocks and shoulders supported on a vertical back. Total body mass measured with a Filizola® digital scale (Brazil) maximum capacity of 150kg, as measured by Inmetro, with its certificate specifying an error margin of approximately 100g. The body mass index (BMI) was calculated with the measures of mass and height, according to the Quetelet equation: $\text{mass (kg)} / \text{height}^2 \text{ (cm)}$. The cut-off points for BMI adopted were those recommended by the IV Brazilian Guideline on Dyslipidemias and Atherosclerosis Prevention of the Department of Atherosclerosis of the Brazilian Society of Cardiology (SBC) [7], that is, low weight (BMI <18.5); eutrophic (BMI 18.5-24.9); overweight (BMI 25-29.9) and obesity (BMI \geq 30). AC was obtained with a tape measure type Incoterm® brand (Brazil), with a measurement definition of 0.1cm. It was measured in the smallest curvature located between the last rib and the iliac crest wi-

thout compressing the tissues [8]. The groups were paired by sex and later by height, BMI, and AC so that there was no sample bias.

Adopted as exclusion criteria individuals with lung diseases, smokers or ex-smokers, with ongoing or last week infection, pregnancy, cognitive deficits, and presence of anatomical changes in the thoracic region. To analyze these variables, an individualized anamnesis was carried out, followed by subsequent palpation and visual inspection in each volunteer. Anthropometric data for the sample are shown in Table I.

Table I. Anthropometric parameters of the type I obesity and eutrophic groups.

Variables	Eutrophic (n = 20)	Obese (n = 20)	P value
Body mass (kg)	63±8.6	94±12.7	<0.01
Height (m)	1.71±0.11	1.70±0.11	0.79
BMI (kg/m ²)	21±2.1	32±2.9	<0.01
Age years	22±3.8	24±6.4	0.15
Abdominal circumference (cm)	77±7.2	102±7.8	<0.01

BMI = Body Mass Index.

Ethical criteria

This study was submitted and approved by the Ethics and Research Committee of Faculdade Adventista da Bahia with CAAE: 1691019.4.0000.0042. All volunteers received information about the research, at which time the risks and benefits that the work could generate according to the resolution of the National Health Council 466/12 were made explicit.

Data collect

For the measurement of Maximum Respiratory Pressures (MRP), an analog manovacuometer (CriticalMed, USA, 2002) was used, with an operational range of $0 \pm 300\text{cmH}_2\text{O}$, properly equipped with a rigid plastic nozzle adapter, containing a small hole of 2 mm of internal diameter, serving as a relief valve, to prevent the increase of pressure in the oral cavity, generated exclusively by contraction of the buccinator muscle [9]. A disposable circular cardboard nozzle (De Marchi) was used.

Before starting data collection, participants were informed about the purpose of the study and the procedures that would be performed for the collection. Also, the volunteers were shown the correct way to perform the breathing maneuvers, that is, use the diaphragm for inspiration and keep the lips firmly attached around the mouthpiece so that there was no air leakage [10].

The volunteer was placed in sedation, with the spine erect, then instructed to perform a slow expiration maneuver followed by a quick and forced inspiration with a nose occluded by a nose clip. The maneuver was repeated until the highest value found was identified, and the last maneuver could not have the highest MIP and MEP value, when this occurred a new maneuver was requested, avoiding the learning effect of the test, as shown in Figure 1.

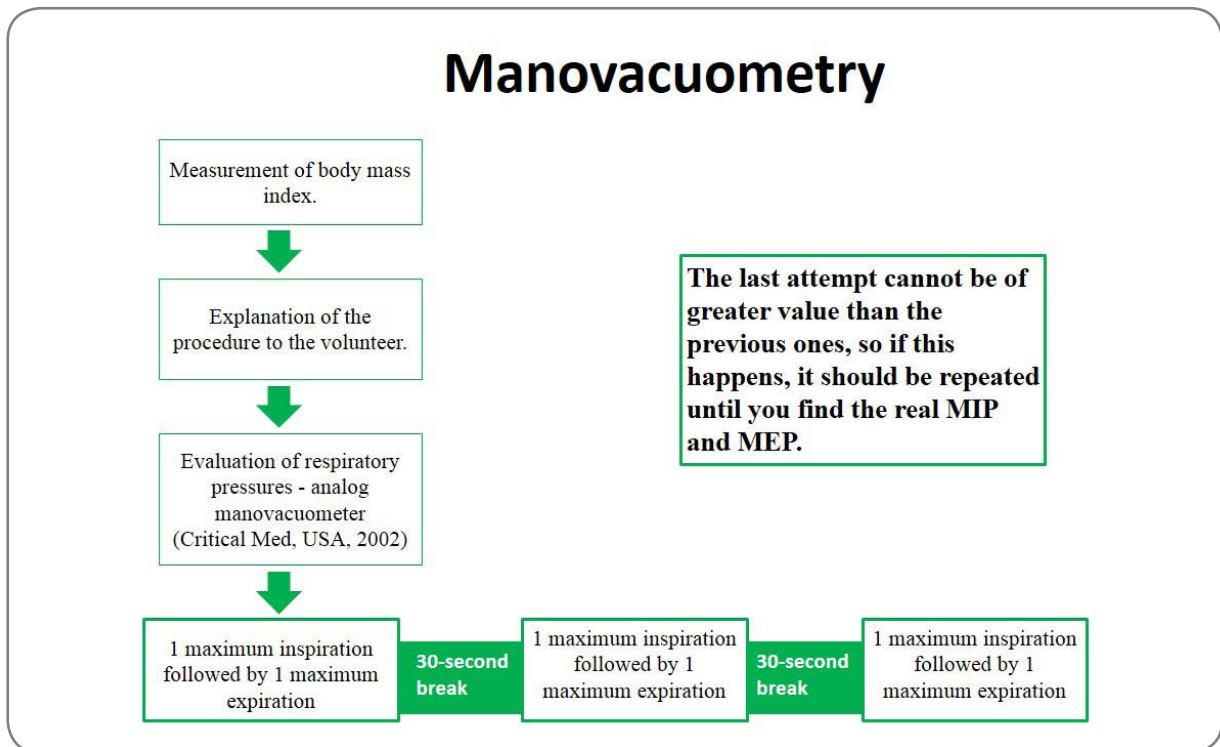


Figure 1. Procedures were performed to collect inspiratory pressures and maximum expiratory pressures (manovacuometry).

Sample sufficiency calculation and statistical analysis

Initially, the sample size was calculated using the WinPep program version 11.65, based on pre-existing results in the literature. Using a difference of 13cmH₂O between the means of MIP and MEP and a standard deviation of 15 for both groups, with a statistical power of 80%, totaling 40 individuals. All were selected for convenience and divided equally into two groups (obese and eutrophic).

For descriptive analysis, the mean and standard deviation were used because it is a linear sample, confirmed after the Shapiro-Wilk normality test, with a $p = 0.39$. To compare the values of MIP and MEP between the groups evaluated, the two-way unpaired Student's t-test was used. The correlations between quantitative variables (BMI and MIP, BMI and MEP, AC and MIP, AC and MEP), were analyzed using Pearson's correlation coefficient, with a significance level of 5%. The BioEstat 5.0 program was used and a $P < 0.05$ was adopted as significant.

Results

Table II expresses the VMS values of the individuals studied. It is observed that there was no significant difference between the groups, both for MIP and for MEP ($p > 0.05$). Also, MIP and MEP remained homogeneous when assessed by sex subgroup ($p > 0.05$).

The analysis of Table III showed that there is no correlation between anthropometric variables and MIP and MEP at the crossings between BMI and MIP, BMI and MEP, and AC with MIP. However, there was a moderate correlation in the AC crossing with MEP of the eutrophic group.

Table II. Ventilatory muscle strength in obese and eutrophic individuals.

Variables	Eutrophic group	Obese group	P-value
Total sample (MIP)	145±70	147±73	0.91
Total sample (MEP)	135±27	133±28	0.93
Male (MIP)	199±21.4	205±12.5	0.68
Male (MEP)	156±10	153±10	0.98
Female (MIP)	64±5.7	60±5.3	0.79
Female (MEP)	100±5.6	101±8.7	0.86

MEP = Maximum Expiratory Pressure in cmH₂O; MIP = Maximum Inspiratory Pressure in cmH₂O.

Table III. Correlation between body mass index (BMI) and abdominal circumference (AC) with the ventilatory muscle strength (VMS) variables.

Crossings	Total sample		Eutrophic		Obese	
	r-value	p-value	r-value	p-value	r-value	p-value
BMI and MIP	-0.02	0.90	-0.05	0.82	-0.15	0.52
BMI and MEP	-0.29	0.07	-0.04	0.85	0.06	0.80
AC and MIP	0.14	0.38	0.35	0.13	0.14	0.55
AC and MEP	-0.15	0.35	0.46	0.04	0.07	0.78

* Pearson's correlation test.

Discussion

The data in this study show that obese individuals did not have VMS other than eutrophic individuals. Also, we see that there is a positive correlation between AC of eutrophic individuals and MEP. The strength of the result is given by the criteria used to ascertain this situation, such as the presence of a hole in the monovacuumeter, including only sedentary people, of both sexes and without any disease resulting from obesity. Some reasons help to explain the results of our study, of which the mutation of skeletal muscle fibers, somatotrophic profile, and type of obesity studied.

Although hypertrophy of adipose tissue imposes a mechanical disadvantage in the axial and appendicular skeleton, studies have been showing muscle-skeletal adaptations that potentially compensate for such disadvantages. Rolland *et al.* [11], measured 1,454 women and found that the obese women studied presented greater muscular trophism than the eutrophic ones and, except hand grip strength, the measures of global muscle strength were significantly higher in obese women than in eutrophic women. Thus, the probable muscular adaptations are reinforced, allowing obese individuals to maintain the strength of the skeletal muscles, which correlates with the results of our study.

Reasons, why the obese individuals studied, did not present a lower VMS may be directly linked to adaptations in the respiratory musculature. Type I skeletal muscle fibers have higher amounts of mitochondria, which in turn make them predominantly aerobic and resistant to fatigue; type II fibers are more powerful and less resistant, subdivided into two classes: IIa and IIx respectively. Type IIa fibers are intermediate, contain a small amount of myoglobin, and use the combination of oxidative and glycolytic metabolism to produce ATP; type IIx fibers have the largest diameter, produce the most strength and depend primarily on anaerobic (glycolytic) metabolism [12].

Studies on the skeletal musculature of individuals with obesity have pointed out important markers of mutation of striated skeletal fibers [13-16]; these findings demonstrate a reduction in oxidative capacity, in addition to fewer mitochondria and a reduction in oxidative fatty acid metabolism. Tanner *et al.* [17] performed biopsies of the rectus abdominis expiratory muscle of women undergoing bariatric abdominal surgery; these women had an increased percentage of type IIx muscle fibers and a reduced percentage of type I fibers about eutrophic ones. These findings converge with the idea raised in this study, since we measure only strength and not resistance as assessed in other studies [18], therefore, we suggest the hypothesis that the obese individuals studied have increased amounts of type II muscle fibers, which helps to overcome the disadvantage mechanics generated by adipose tissue hypertrophy.

Studies [19-21] have shown a relationship between body somatotype and physical performance. To understand this, it is important to highlight the physical characteristics of each biotype: the ectomorph has a thin body composition, characterized by the development of the ectoderm; the mesomorph, developed from the embryonic mesoderm, has a muscular or robust body complexion, with a consequent increase in AC but maintaining normal BMI standards; endomorphic individuals come from the development of the endoderm and have a heavy or fat body build. Chaouachi *et al.* [21] studied the association between the somatotrophic profile and the physical fitness of police officers and found that the mesomorphic somatotype was positively associated with increased maximum and explosive strength. Reasons why the increase in AC correlates positively with MEP of the eutrophic group, may be linked to the heterogeneity of the somatotrophic profile of these individuals. Therefore, it is suggested that eutrophic individuals with mesomorphic biotypes have a mechanical advantage over ectomorphs. However, the fact that eutrophic people were not evaluated for body biotype, made it impossible to make a more specific comparison in the group for better conclusions.

Although some studies [5,22] point to a decrease in VMS due to hypertrophy of adipose tissue, especially in the upper body, it is important to note that most of them measure individuals with morbid obesity or overweight [6] ($BMI \geq 50\text{kg}/\text{m}^2$). Also, most studies that report a decrease in VMS in obese individuals measure patients with obstructive sleep apnea syndrome, alveolar hyperventilation syndrome, among other lung diseases. In our study, we included only sedentary individuals without any illness due to obesity.

Costa *et al.* [22] correlated the anthropometric data of obese and eutrophic women with VMS. In this study, obese women had a higher VMS and there was no correlation between AC and waist-to-hip ratio with the monovacuumetry of the two groups. The comparison of AC with the VMS variables is similar to that of our study, however, that author's sample was not differentiated as to the types of obesity, which may explain the discrepancies in the results of the VMS comparison.

Magnani and Cataneo [6] found that obese individuals grade II and III did not show restriction in MIP and MEP compared to values predicted in the literature. Also, in your sample, it is noted that there was no correlation between an increase in the abdominal waist and a decrease in VMS. These results corroborate with our research, however, it is noteworthy that Magnani and Cataneo measured only obese individuals, not correlating AC with the VMS variables of eutrophic individuals, a factor evaluated in our study.

Although obese individuals have no difference in VMS, this does not mean that this population is healthier, since pre-existing studies in the literature show losses caused by the increase in fat mass [23]. Also, the benefits of a good quality of

life and the practice of physical activities for maintaining human health are already proven [24,25].

Inferring the application of the results of this sample, it is suggested that, despite the mechanical disadvantage offered by obesity, mechanisms of physiological adjustments compensate for this problem in the degree I obese individuals studied, and not all obese patients present respiratory muscle impairment. Also, it is suggested that further studies be carried out, evaluating the somatotrophic profile of the sample, in addition to muscle endurance tests and not just strength.

Conclusion

The statistical data obtained from maximal inspiratory expiratory pressure, in both sexes, demonstrated the similarity of the behavior of the inspiratory and expiratory muscles of obese grades I and eutrophic. Therefore, in this sample of individuals, we concluded that grade I obesity does not promote changes in ventilatory muscle strength.

Acknowledgment

To the administrative director of the Immunopathology Laboratory of Faculdade Adventista da Bahia (FADBA), Cachoeira BA - Brazil, where all data collections were carried out.

Potential conflict of interest

No conflicts of interest have been reported for this article.

Financing source

There were no external sources of funding for this study.

Authors' contributions

Research design: Silva WS, Wagmacker DS. **Statistical analysis:** Wagmacker DS. **Data collection and database review:** Silva WS, Mestre ES, Silva ES. **Writing of the scientific text:** All authors contributed to the writing and review of the work. **Intellectually important:** Wagmacker DS.

Academic Link

This article represents the conclusion work of Jailson de Souza Santos Junior and David Eduardo Santos Viana, supervised by Professor Dr^a Djeine Silveira Wagmacker in the Specialization Program in Exercise Physiology, at Faculdade do Centro Oeste Paulista, Bauru, SP, Brazil.

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