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ORIGINAL ARTICLE

Correlation of spirometry with the six-minute walk test in eutrophic and obese individuals

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Summary

Objective: To assess the distance covered by both eutrophic individuals and individuals with different grades of obesity and correlate the data obtained with spirometric values. This study is justified by the existing difficulty in assessing the functional capacity in obese individuals, and by the low cost and good specificity of six-minute walk test (6MWT) in predicting reduced capacity for activities of daily living for any individual. **Methods:** One hundred fifty-four individuals of both genders were assessed after being divided into two groups: G1, obese individuals (n = 93, BMI $\geq$ 30 kg/m^2) and G2, eutrophic individuals (n = 61, BMI 18.5 to 24.99 kg/m^2). The 6MWT was performed using the methodology described by the American Thoracic Society (ATS-2002). Spirometry was performed both before and after the application of a bronchodilator agent (BDA) in accordance with the Guidelines for Pulmonary Function Tests by the Brazilian Society of Pneumology and Phthisiology (SBPT-2002). The statistical analysis, consisting of mean, standard deviation, Pearson's correlation, Student's *t* test and Spearman's correlation, considered $p < 0.05$. **Results:** The 6MWT analysis with spirometry for G1 was positively correlated only with pre- and post-BDA peak expiratory flow rate (PEFR). **Conclusion:** The present study showed a positive correlation between pre- and post-BDA PEFR and the distance covered in the 6MWT in obese subjects, that is, the higher the PEFR, the higher the physico-functional capacity of the individual, and consequently, the greater the distance covered.

Keywords: Walk; spirometry; obesity; exercise test; pulmonary function tests.

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Introduction

Obesity is a worldwide epidemical disease of fat accumulation in the body, caused by excessive and chronic intake of caloric foods linked to a low energy expenditure mainly related to a sedentary lifestyle[1-3].

Etiology and risk factors for the development of obesity are multiple, including genetic and psychological aspects, low metabolic rate, bad dietary habits, endocrine diseases, side effects of drugs and sedentary behavior[2].

The World Health Organization (WHO)[4] indicates that approximately 1.6 billion adults were overweight in 2005 worldwide, and at least 400 million were obese. Projections for 2015 show that 2.3 billion adults will be overweight and over 700 million will be obese.

The second phase of the 2002-2003 Family Budget Survey by the Instituto Brasileiro de Geografia e Estatística (IBGE)[5] demonstrated that out of 95.5 million people ≥ 20 years of age, 38.8 million (40.6%) were overweight, with 10.5 million being considered obese.

The classification of overweight and obesity in adults is expressed by the body mass index (BMI – kg/m^2). This index is defined by the weight in kilograms (kg) divided by the squared stature in meters (m^2). Individuals with a BMI < 18.5 kg/m^2 are underweight; between 18.5 and 24.9 kg/m^2 they are considered normal; between 25 and 29.9 kg/m^2 they are overweight. BMI classifications for obesity are: grade I, a BMI from 30 to 34.9 kg/m^2; grade II, between 35 and 39.9 kg/m^2; grade III or extreme obesity for BMI ≥ 40 kg/m^2 [2,4,6].

Five decades ago, obesity was recognized to affect lung function, producing mechanical effects reflected on the pulmonary mechanics, possibly leading to a reduced complacency, which may result in a restrictive ventilatory disorder[7-10].

The simple spirometry is a pulmonary function test measuring the air inhaled and exhaled by the lungs and the following pulmonary volumes and capacities: forced vital capacity (FVC); forced expiratory volume in one second (FEV1); forced expiratory flow between 25% and 75% of the FVC ($FEF_{25-75\%}$); VEF1/FVC ratio and peak expiratory flow rate (PEFR)[7,11].

Spirometry is indicated to detect whether a pulmonary dysfunction is present or not; to rate the severity of a known pulmonary disease; to follow-up the pulmonary function under therapy and the disease course; to assess the effects from environmental and occupational exposure; and others[12].

Spirometry is a safe procedure, but increased intracranial pressure, syncope, dizziness, chest pain, paroxysmal cough, risk for infections, bronchospasm, and pneumothorax can occur[12].

Grade III obesity can impair the respiratory system because of perithoracic and abdominal fat accumulation, reducing the expiratory reserve volume (ERV) and the functional residual capacity (FRC), also promoting ventilation/perfusion (V/Q) ratio changes from hypoxemia rest and supine hypoxemia, likely because of small airway closure[13].

The six-minute walk test (6MWT) is a practical and simple assessment of the submaximal level of functional exercise capacity for activities of daily living[14]. It measures the distance a person can walk fast on a flat and hard surface over six minutes. The test assesses and integrates responses from all systems involved during the exercise (cardiovascular, respiratory, neuromuscular, and metabolic systems), but it does not provide specific and isolated information[15].

The 6MWT is mainly indicated for: comparing pre- and post-treatment phases; measuring the functional status; and predicting the morbidity and mortality from cardiopulmonary diseases. The primary measurement is the total distance covered. The secondary measurement includes muscle fatigue and dyspnea, assessed by the modified Borg Scale or a Visual Analogue Scale. The last measurement would be the saturation of peripheral oxygen (SpO_2), measured by a pulse oximeter[16]. Absolute contraindications are: stable and unstable angina, recent acute myocardial infarction; relative contraindications are: heart rate at rest higher than 120 bpm; systolic blood pressure (SBP) higher than 180 mmHg, and diastolic blood pressure (DBP) over 100 mmHg[15].

From the literature review, no specific studies of reference values for physical-functional and pulmonary capacity in obese individuals compared to eutrophic individuals were found. The correlation of these capacities has a considerable clinical relevance, as it can contribute to setting strategies for preventive treatment and complication treatment in obesity in order to offer better respiratory conditions with an appropriate choice of the therapeutic method to help individuals to be embedded into a treatment group.

The rationale for this study was the difficulty in assessing functional capacity in obese individuals. The 6MWT has a low cost, is easily applied, and its good specificity in predicting reduced capacity for the activities of daily living in any individual has also influenced the choice.

The present study aimed to assess the influence of excess body weight on pulmonary and physical-functional capacity, correlating variables of spirometry testing and the six-minute walk test in different grades of obesity and in eutrophic individuals.

Methods

The sample consisted of 154 sedentary volunteers of both genders between 20 and 59 years of age, non-smokers and divided into two groups: study group (G1) formed by 93 obese subjects (BMI ≥ 30 kg/m^2) and control group (G2), consisting of 61 eutrophic subjects (BMI 18.5 to 24.99 kg/m^2). G2 should have a normal spirometry and all volunteers signed an informed consent and concluded the tests proposed.

Volunteers with physical-mental changes who might not understand the test performance, such as in behavior disorders, with associated and decompensated diseases (heart, metabolic, pulmonary, neuromuscular, and musculoskeletal diseases) significantly limiting the walk, or disagreement about any procedure proposed were excluded.

The present study was approved by the Ethics Committee of the Universidade Católica de Brasília (CEP/UCB 052/2009).

Volunteers were instructed to wear comfortable clothes, appropriate sneakers for a walk, to use their medication normally and not to exercise vigorously over the two hours preceding the tests. An evaluation form containing personal data, vital signs, anthropometric measurements, diseases associated, dyspnea grade, life habits, spirometric parameters and 6MWT was designed.

Initially, volunteers were weighed on a digital scale (Filizola) with 100 g increments and their weight was noted. Stature was checked by a stadiometer (Cardiomed) affixed to the laboratory wall. Heart rate (HR) and saturation of peripheral oxygen (SpO_2) were collected from the pulse oxymeter (Moriya®); blood pressure (BP) was measured by a sphygmomanometer (Missouri) and a stethoscope (Littman) on the left upper limb. Waist circumference (WC) was measured at the midpoint between the last costal border and the iliac crest; hip circumference (HC) was measured at the femur major trochanter level, in an orthostatic position. WC and HC were measured by a 13 mm wide long flexible measure tape (Kapor) with one-millimeter accuracy. Waist/hip-ratio (WHR) was calculated following the circumference measurement.

The 6MWT was performed using the methodology specified by the American Thoracic Society (ATS-2002)[15] in a hard surface, covered, long, flat and walled corridor which was 30 m long; meter-by-meter marks were done and two cones signaled the walk turn. Parameters such as BP, HR, SpO_2, and the modified Borg scale (it assesses subjectively the degree of effort, assigning a grade from 0 to 10) were collected early and late over the walk. When the test was terminated, the distance covered was calculated through notes of the number of turns performed by the volunteer.

The volunteer was instructed to undergo the test as fast as possible without running for six minutes, walking from one cone to another during the stipulated time and the test could be interrupted at any time.

Every minute the investigator approached the volunteer and said encouragement phrases, such as: "You are doing well!" and "Only a few minutes left!". At these points, SpO_2 and HR were verified in the oxymeter connected to the volunteer through an elastic belt to avoid many displacements and swings and keep the safety of the equipment use.

As soon as the 6MWT was finished, the volunteer should sit down and rest for approximately 30 minutes to undergo the spirometry pre- and post-bronchodilator agent (Spirometer: V Max 229 Sensor Medics), performed by a trained technician, that is, the volunteer underwent spirometry and after the bronchodilator agent (BDA) administration, he/she waited for 15 minutes to undergo a new spirometry so that the response to the bronchodilator agent could be evaluated.

The spirometry was performed with the volunteer sitting and using disposable mouthpieces for individual use with nose clip, in accordance with the recommendations in the Guidelines for Pulmonary Function Tests (Brazilian Society of Pneumology and Phthisiology: SBPT-2002)[11]. Spirometry report was made by a pneumologist in charge of the Cardiopulmonary Rehabilitation Laboratory of Universidade Católica de Brasília.

In the statistical treatment by SPSS 17.0 data exploratory analyses were made to identify possible misconduct cases or extreme values, normality test for variables, and descriptive statistics with mean and standard deviation for age, BMI and the other pre- and post-BDA spirometric values.

Pearson coefficient of correlation was used to verify a possible association between BMI and the distance covered the WC, and the distance covered by the 6MWT. The same test was used to verify the association between distance covered and spirometric parameters.

Student's *t* test was used to compare the spirometry variables among the groups for independent samples. This test was also used to compare HR, SpO_2, respiratory rate (RR), BP, WC, WHR and distance covered with the 6MWT in different groups. HR in early 6MWT was compared with end HR by the paired *t* test.

Spearman test was used to correlate the obesity grade with the distance covered and the spirometry. All analyses were performed with a 5% significance level adopted.

Results

The study included 154 subjects, with 93 in G1 and 61 in G2. In the obese group, mean age was 37.6 ± 10.5 years and BMI was 36.73 ± 5.35 kg/m^2; in the eutrophic group, mean age was 29.6 ± 9.0 years and BMI was 22.5 ± 2.05 kg/m^2. In G1, 64.5% were females and 35.5% were males; in G2, 73.8% were females and 26.2% were males. Regarding the obesity grade, the sample included 42 grade I obesity subjects (45.2%), 28 grade II obesity subjects (30.1%), and 23 grade III obesity subjects (24.7%).

As the groups were compared concerning WC, WHR and distance covered over the 6MWT measurements, significant differences were observed for all variables across the groups. Obese subjects had a WC 114.7 ± 16.7 cm versus 75.8 ± 9.3 cm in the eutrophic group. As for WHR, the mean was 0.93 ± 0.07 cm for obese subjects and

0.79 ± 0.07 cm for eutrophic group. In the 6MWT, obese subjects covered a mean of 531.5 ± 57.2 m, and eutrophic subjects, 589 ± 45.1 m.

Regarding HR, SpO_2 and RR at rest, the groups are statistically equal, with means and standard deviation shown in Table 1.

Pearson coefficient of correlation identified a negative and moderate correlation ($p = 0.001$) between BMI and the distance covered over the 6MWT; a negative and slight association ($p = 0.001$) was demonstrated between the distance covered and WC in G1 and, in G2, there was no significant correlation between both variables.

Analysis of HR and SpO_2 evolution in both groups every minute in the 6MWT demonstrated significant correlation for HR at the third ($p = 0.014$), fifth ($p = 0.016$), and sixth (0.031) minutes. G1 had a lower HR than G2 all over the test. However, SpO_2 had no difference between both groups.

Systolic (SBP) and diastolic (DBP) BP compared between the groups showed differences for all initial and end variables ($p = 0.001$) in 6MWT, with G1 having the highest variable values.

As HR was compared before and at the end of the 6MWT in each group, a statistical significance was observed ($p = 0.001$), with G1 showing a mean initial and end HR in the 6MWT 84.5 ± 10.7 bpm and 133 ± 17.4 bpm, respectively, lower than G2, which had a mean initial 84.6 ± 13.1 bpm and 139.1 ± 16.8 bpm for the end-of-the test HR.

Before the 6MWT, the exertion perception on the modified Borg scale was chosen. In G1, 57 volunteers initiated the walk with no exertion (Borg 0), 11 with minimal exertion (Borg 0.5), 7 with very little exertion (Borg 1), 12 with little exertion (Borg 2) and 6 with moderate exertion (Borg 3). In G2: 46 volunteers initiated the walk at Borg 0, 9 at Borg 0.5, 2 at Borg 1, 3 at Borg 2, and only one at Borg 3.

At the end of the 6MWT, the exertion perception for G1 was: 2 obese subjects ended the walk at Borg 0; 6 at Borg 0.5; 8 at Borg 1; 24 at Borg 2; 33 at Borg 3; 8 had a nearly severe exertion (Borg 4); 6 had severe exertion (Borg 5); 4 had profound exertion (Borg 7); and 2 maximum exertion (Bort 10). In G2: 4 eutrophic subjects had Borg 1; 4 had Borg 0.5; 15, Borg 2; 26, Borg 3; two, Borg 4; seven, Borg 5; and 3 Borg 7.

As the association between obesity grade and distance covered over the 6MWT was verified, Spearman coefficient demonstrated a negative and moderate correlation between the variables ($p = 0.001$), i.e., subjects with grade I obesity covered a longer distance than the other obese subjects.

The spirometric parameters pre- and post-BDA FEV1/FVC ($p = 0.0001$) and post-BDA $FEF_{25-75\%}$ ($p = 0.04$) showed a negative correlation compared with all the spirometric parameters in both groups, with G1 showing reduced values related to G2.

When the obesity grade was correlated with the spirometry parameters by Spearman test, a negative association of the peak expiratory flow rate was found. For pre-BDA PEFR the p-value was 0.007, whereas for post-BDA PEFR $p = 0.02$, i.e., the higher the obesity grade, the lower the peak flow reached. For the other parameters, there was no significant correlation.

The mean spirometric parameters for pre-BDA FVC and post-BDA FEV_1 were lower in grade II obese subjects related to grade III obese subjects, differing from the other parameters which had decreasing means as obesity increased (Table 2).

The spirometry had five different spirometric reports for G1, with 84 revealing a normal spirometry (90.3%); five had a slight reversible post-BDA obstructive ventilatory disorder (5.4%); three had a slight restrictive ventilatory disorder (3.2%) and only one subject had a mixed ventilatory disorder with a moderate nonreversible post-BDA obstructive component (1.1%).

As the association between 6MWT and the sample spirometry variables was analyzed, a slight positive correlation was found for pre-and post-BDA FEV_1/FVC, post-BDA $FEF_{25-75\%}$, pre- and post-BDA PEFR, indicating the longer the distance covered, the higher these spirometry parameters, as shown in Table 3.

Table 1 – Comparison between groups: HR, SpO2, RR, WC, WHR, and distance covered over the 6MWT

Variable	G1 (n = 93)	G2 (n = 61)	t	p
HR at rest (bpm)	84 ± 10.7	84 ± 13.1	-0.01	0.99
SpO_2 at rest (%)	95 ± 1.7	95 ± 2.1	-0.24	0.80
RR (breaths per minute)	15 ± 3.5	16 ± 3.6	-1.81	0.07
WC (cm)	114.7 ± 16.7	75.8 ± 9.3	18.40	0.001*
WHR (cm)	0.93 ± 0.07	0.79 ± 0.07	11.60	0.001*
Distance covered over the 6MWT (m)	531.5 ± 57.2	589.0 ± 45.1	-6.60	0.001*

*p < 0.05 is significant.

HR, heart rate; SpO2, oxygen peripheral saturation; RR, respiratory frequency; WC, waist circumference; WHR, waist/hip ratio; m, meters; bpm, beats per minute; cm, centimeters; %, percentage.

Table 2 – Mean percentage of spirometry predicted values in the obese group, according to the obesity grade (n = 93)

Spirometry (predicted %)	Grade I (n = 42)		Grade II (n = 28)		Grade III (n = 23)	
	Pre-BDA	Post-BDA	Pre-BDA	Post-BDA	Pre-BDA	Post-BDA
FVC	102.3 ± 14.6	101.1 ± 14.2	96.8 ± 12	96.6 ± 12	98.6 ± 12.2	99.5 ± 11.4
FEV_1	100.8 ± 14	101 ± 13.8	95 ± 11.8	96.7 ± 12.4	94.6 ± 13	96.8 ± 13.2
FEV_1/FVC	82.9 ± 3.9	84.3 ± 3.8	82.3 ± 4.3	83.5 ± 3.9	81.3 ± 6.6	82.3 ± 4.4
$FEF_{25-75\%}$	100 ± 21.9	107.7 ± 23.2	93.5 ± 23.2	101.6 ± 25.4	87.4 ± 24.1	94.9 ± 24.4
PEFR*	109.3 ± 17.7	107.3 ± 16.7	103.5 ± 17.1	106.9 ± 18	89.1 ± 16.3	93.5 ± 16.8

* $p < 0.05$ is significant.
Pre-BDA, pre-bronchodilator agent; Post-BDA, post-bronchodilator agent; FVC, forced vital capacity; FEV_1, forced expiratory volume in one second; $FEF_{25-75\%}$, forced expiratory flow between 25% and 75% of the FVC; FEV_1/FVC = FEV_1/FVC ratio; PEFR, peak expiratory flow rate.

Table 3 – Correlation between the whole sample of the distance covered over 6MWT and spirometry (Pearson Coefficient)

Spirometry (predicted %)	6MWT (n = 154)	
	r	p
Pre-BDA FVC	0.050	0.54
Post-BDA FVC	-0.008	0.92
Pre-BDA FEV_1	0.137	0.09
Post-BDA FEV_1	0.112	0.16
Pre-BDA FEV_1/FVC	0.213	0.008*
Post-BDA FEV_1/FVC	0.29	0.001*
Pre-BDA $FEF_{25-75\%}$	0.148	0.07
Post-BDA $FEF_{25-75\%}$	0.196	0.015*
Pre-BDA PEFR	0.174	0.031*
Post-BDA PEFR	0.205	0.011*

*$p < 0.05$ is significant.
Pre-BDA, pre-bronchodilator agent; Post-BDA, post-bronchodilator agent; FVC, forced vital capacity; FEV_1, forced expiratory volume in one second; $FEF_{25-75\%}$, forced expiratory flow between 25% and 75% of the FVC; FEV_1/FVC = FEV_1/FVC ratio; PEFR, peak expiratory flow rate.

As the same analysis of 6MWT with the spirometric parameters only for G1 is performed, a weak positive correlation was observed only for pre- (p = 0.007) and post-BDA (p = 0.005) PEFR, i.e., the longer the distance covered, the higher the PEFR value in the obese group, whereas for G2 there was no significant correlation.

Discussion

According to Enright and Sherril[17], there are formulas predicting the distance covered over the 6MWT regarding age, weight and stature. In the study by Barata et al.[18], the attempted establishment of specific formulas for Brazilian healthy elderly individuals was frustrated due to small sample. No studies using specific reference values or formulas for obese individuals were found and so predicting equations were not used in the current study.

According to ATS[15], the 6MWT should be discontinued if the volunteer have chest pain, unbearable breathlessness, leg cramps, dizziness, excess sweating and pallor. In the study, only an eutrophic female volunteer needed to close the test from severe back pain.

The eutrophic females covered a mean of 583.44 ± 43.75 m versus 522.61 ± 48.54 m for obese females, and eutrophic males obtained a mean covered distance 604.68 ± 46.47m versus 547.81 ± 68.16 m for the obese ones. This data bears out the study by Perecin et al.[19], which concluded eutrophic individuals walk longer distances than obese individuals. In addition, they confirmed what ATS presents[15] – two of the factors reducing the distance in 6MWT would be a high body weight and female gender. Duration of obesity, on average 10 years for G1, can also have contributed to the reduced distance covered, as complications and changes are known to arise over the time.

The current study shows a negative and moderate association between the distance covered in the 6MWT and BMI, which was not observed by Pelegrino et al.[20] in a study conducted with patients presenting a chronic obstructive pulmonary disease, with no significant association between distance and BMI.

A slight negative association was observed when the obesity grade and the distance covered overt the 6MWT were correlated, in which the lower the obesity grade, the longer the distance covered. The same result was found by Pires et al.[21] with different BMI grades.

The oxygen desaturation peak over the 6MWT, in this study, was maintained over the first minute for obese subjects and over the first three minutes for eutrophic subjects, unlike the study by Brunetto et al.[22] with COPD patients, who reached the peak at the third and sixth minutes of the test, demonstrating a lack of physical functional fitness in obese individuals.

In obesity, the function of respiratory muscles is impaired from the increased resistance they must overcome and from the reduced capacity of these muscles[23]. Increased body fat can affect pulmonary function tests, with a slight decrease in pulmonary volumes being associated.

As shown by Collins et al.[24], FVC, VEF_1 and total pulmonary capacity (TPC) are significantly decreased in patients with elevated body fat. This was also observed in the present study, in which the mean predicted percentage of spirometric parameters decreased as the obesity grade rose.

The present study results bear out data by Domingos-Benício et al.[25], who found no significant differences between FVC and FEV_1 values in both eutrophic and obese subjects. However, the results contradict these authors' statement that there would be a difference in the FEV_1/FVC ratio between both groups.

According to Teixeira et al.[10], the higher the excess weight, the lower the FEV_1/FVC ratio and $FEF_{25-75\%}$. There is a controversy in the study by Jones and Nzekwu[26], which showed obesity is associated with a high FEV_1/FVC ratio. The present study found a negative correlation for post-BDA $FEF_{25-75\%}$ between both groups, indicating this value is reduced in the obese group.

Obese people often complain of dyspnea, even though they do not have a demonstrable lung disease[27]. Obesity can cause a limited airway flow, with reduced VEF_1 and FVC. Unlike asthma, these reductions are typically symmetrical and result in a preserved FEV_1/FVC ratio. A number of authors demonstrate the FEV_1/FVC ratio is increased in obesity, consistently with the restrictive physiology[9,28].

It is noteworthy that out of 93 obese subjects, only three had a mild restrictive ventilatory disorder diagnosed by spirometry, i.e., 3.2%. In the study by Silva et al.[13], over 10% of the 50-patient-sample were found with a mild to moderate restriction grade, and Faintuch et al.[29] diagnosed 20.9% of mild restrictive grade in 46 candidates for bariatric surgery.

Airway narrowing from obstructive phenomena associated with weight gain could explain the other diagnoses in the study, as Teixeira et al.[10] believed in a study of grade II and III obese subjects.

According to Pereira[11], airway obstruction is a feature in asthma, emphysema, chronic bronchitis, bronchiolitis, and bronchiectasis. However, in the present study, no volunteer had any of these diseases previously diagnosed.

The 6MWT reproducibility seems to be higher than that for FEV_1 in patients with COPD[15]. A number of studies show significant associations between the distance over the 6MWT and FEV_1[20,30]. However, Pereira[11] states FEV_1 is weakly correlated with exercise capacity and symptom improvement in patients with COPD.

The present study showed a positive correlation between pre- and post-BDA PEFR and the distance covered over the T6WT in obese subjects. PEFR is an exertion-dependent expiratory parameter, reflecting the airway caliber. Therefore, when airways are narrow and have a reduced PEFR, the distance covered over the 6MWT will also be reduced, enabling a cause and consequence hypothesis.

A positive correlation between the pre- and post-bronchodilator agent peak expiratory flow rate and the distance covered over the 6MWT can be found in obese individuals, i.e., the higher the PEFR, the higher the individual physical-functional capacity and the longer the distance covered.

A relevant point in the study was obese group covered a shorter distance over the 6MWT compared with the eutrophic group, with a significant difference. This shows the interference a number of years of obesity settlement can cause on the individual and demonstrates the clinical importance of this finding for further studies.

Another important finding was the higher the obesity grade, the bigger the repercussions these individuals could show in spirometric parameters, which were reduced in this group.

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