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The Impact of Overweight on Flexibility and Functional Capacity

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Abstract

Obesity is a health problem worldwide, with a significant impact on the mortality of individuals. However, considering the importance of preventive management, few studies have addressed the predictors of functional impairment in overweight subjects. The present study aimed to verify the differences in functional variables in overweight volunteers compared to eutrophic subjects, to determine the independent predictors of functional capacity in overweight subjects and to provide a model that can predict exercise capacity in this population. Seventy-four physically active participants (both sexes, aged 18 to 60 years) were evaluated and stratified into two groups: eutrophic (n=45, 33 ± 11 years, 76% females) and overweight (n=29, 37 ± 12 years, 41% females), according to body mass index (BMI). All volunteers were submitted to clinical, anthropometric, flexibility, muscle strength and endurance evaluation and maximal exercise testing. Differences between groups were verified by Independent T test or Mann-Whitney. Uni and multivariate linear regressions were performed to verify the independent predictors of functional capacity in the overweight group. The overweight individuals were predominantly male (58.6%), with iliopsoas ($p=0.009$), pectoral ($p<0.001$) and piriformis ($p=0.003$) shortening, and with lower values of peak oxygen uptake (VO_{2peak}) ($p=0.012$). In the final multivariate model, BMI and body fat percentage were the only independent predictors of functional capacity in overweight volunteers and VO_{2peak} can be predicted by the model $VO_{2peak}=85.161 - (0.747 \times \text{BMI}) - (0.925 \times \text{body fat percentage})$. Overweight individuals already show musculoskeletal and functional changes when compared to eutrophic ones. Preventive strategies should be adopted in this population, aiming to prevent musculoskeletal and functional dysfunctions that may compromise the functional capacity of these individuals.

Keywords: Obesity; Overweight; Functional capacity

Introduction

Obesity is a serious medical condition and a public health problem worldwide [1,2], considered as one of the main risk factors for diabetes mellitus [3] and cardiovascular diseases [4,5]. If the actual trends continue, by 2025, global obesity prevalence will reach 18% in men and surpass 21% in women [6].

The data are worrying. The prevalence of obesity increased from 3.2% in 1975 to 10.8% in 2014 in men, and from 6.4% to 1.9% in women [6]. Obese subjects were at increased risk for sudden cardiac death (HR 1.79) [7] and death by general cause among subjects aged 50-69 years (HR 1.14) [8]. In health-related quality of life, obesity can increase problems in mobility, self-care, and usual activities and pain/discomfort [9].

The impact of obesity on morbidity and mortality are well documented [10] but few studies have verified its effects on functional capacity and quality of life. Previous study [11] reported that excess weight was related to worse physical component of quality of life. However, the associations between obesity and functional capacity are little known and it is necessary to provide an overview of functional deficits in obese patients [12]. Furthermore, preventive management of people with obesity should start as soon as possible. Despite the clinical meaning, studies addressing the overweight population, with a body mass index (BMI) greater than 25 kg/m^2 and less than 30 kg/m^2, are scarce.

Some considerations are highlighted. Firstly, it is necessary to verify if overweight individuals, even presenting low risk when compared to obese subjects, have musculoskeletal dysfunction and exercise intolerance correctable during physiotherapy treatment. In addition, exercise capacity, represented by peak oxygen uptake (VO_{2peak}), is an important clinical parameter in health status. Therefore, the predictors of VO_{2peak} in the overweight population should be verified. Establishing the determinants of functional impairment in overweight patients, physiotherapists can take effective preventive and therapeutic measures. And, finally, an equation to predict the VO_{2peak} in the overweight population should be investigated. The proposed model may help in the functional evaluation of this population in situations where the maximum test cannot be performed.

Thus, the present study was addressed to verify the functional differences in eutrophic and overweight subjects and to determine the independent predictors of functional capacity in overweight individuals, as well as to provide a model to estimate VO_{2peak} in this population.

Methods

Study design

This cross-sectional study was approved by the institutional review committee and the subjects gave informed consent. Criteria for inclusion were age between 18 and 60 years, BMI greater than 25 kg/m^2 and less than 30 kg/m^2 [1,2], moderate physically active according to International Physical Activity Questionnaire (IPAQ) [13], without history of muscle injury in the last 6 months, without arterial hypertension, diabetes mellitus and any comorbidities that change the test results and the ability of performance all tests. Patients in nutritional supplementation, with acute conditions such as fever, abnormal dyspnea and/or fatigue, high levels of systolic and/or diastolic blood pressure (above 160 and 90 mmHg) and high values of heart rate at rest (above 120 bpm) were excluded. The inability to reach maximum intensity during the exercise test was also an exclusion criterion.

The previously selected subjects underwent clinical assessment, anthropometric measurements, evaluation of flexibility and muscle strength and endurance and exercise testing.

Anthropometric measurements

The anthropometric data were evaluated by body mass index (BMI), body fat percentage, waist circumference and waist-hip circumference. BMI was calculated using the formula weight (kg)/$height^2$ (m). In the body fat percentage evaluation, skinfolds were measured from seven sites and body fat percentage was calculated according to standardized formulas [14,15]. The waist circumference was measured at a level midway between the lowest rib and the iliac crest. And, finally, the waist-hip ratio was the ratio between the waist circumference and the girth of hip at the level of major trochanter.

Flexibility and muscle strength and endurance

The shortening of the quadriceps, hamstring and iliopsoas, pectoral, gastrocnemius and piriformis muscles was based on the Flexitest [16], a test previously validated in the Brazilian population for the assessment of flexibility.

Muscle strength was assessed by handgrip, an indicator of general strength, using the Jamar© dynamometer. The subject was in sitting position with feet on the floor. The dominant arm was placed in the table in such a position that shoulder in 0° flexion, 20° abduction, elbow flexed in 90°, forearm in mid prone position and wrist slight extension [17]. The volunteer was instructed to perform the maximum muscle contraction possible on the dynamometer. The test was repeated 3 times and was considered the highest value.

The assessment of abdominal muscular endurance was verified by the number of abdominal exercises performed during one minute.

Exercise testing

To evaluate the VO_{2peak}, we performed the maximal exercise testing by 1600-meter test [18]. In the test, patients were instructed to walk/run 1600 meters, at the highest possible speed in the treadmill. The VO_{2peak} was calculated by the formula VO_{2peak} = (6.952 + weight - age + sex - time - HRmax reached) × 1000/body weight. In the Brazilian population, the VO_{2peak} calculated by the formula showed good correlation with the VO_{2max} evaluated by the Cardiopulmonary Exercise Testing [19], the gold standard in the evaluation of functional capacity. Blood pressure and resting heart rate were measured at the end of the test and during the recovery period (active rest of one and two minutes). The volunteers who were unable to reach the maximum intensity in the test were excluded.

Statistical analysis

The distribution of data was verified by KolmogorovSmirnov. The descriptive analysis was shown as mean and standard deviation, median and interquartile range (MD/2575%) or absolute number and percentage, as appropriate.

Correlations among variables were verified by Pearson or Spearman correlation test. Differences between eutrophic and overweight group were verified by Independent T test or Mann-Whitney. The level of significance was α<5%.

Uni and multivariate linear regression analysis were performed to determine the factors that were associated with VO_{2peak} in the overweight group. Variables with p-value less than 0.1 in the univariate model were included in the multivariate.

All data were analyzed with Statistical Package for the Social Sciences version 17.0 (SPSS Inc., Chicago, IL, USA).

Results

Sample characteristics

We previously selected 82 individuals and a total of 74 volunteers were included in the present study. The BMI correlated with waist circumference (r=0.799, p<0.001), waist-hip ratio r=0.468, p<0.001), handgrip strength (r=0.292, p=0.013) and peak oxygen uptake (r=-0.463, p<0.001). The fat percentage correlated with waist-hip ratio (r=-0.230, p=0.050), handgrip strength (r=-0.594, p<0.001), abdominal endurance (r=-0.236, p=0.045) and peak oxygen uptake (r=-0.680, p<0.001).

The overall study population were stratified according to BMI into eutrophic (n=45) and overweight (n=29) groups. It was verified that the overweight group was predominantly male (58.6%), with higher BMI (p<0.001), waist circumference (p<0.001) and waist-hip ratio (p=0.001). There was no significant difference in the body fat percentage between the groups (p=0.269). In addition, overweight individuals had a higher prevalence of iliopsoas (p=0.009), piriformis (p=0.003) and pectoral (p<0.001) shortening. On exercise testing, VO_{2peak} was significantly lower in the overweight group (p=0.012). Clinical, demographic, anthropometric and functional parameters are shown in Table 1.

Variable	**Eutrophic group (n=45)**	**Overweight group (n=29)**	**p-value**
Age, years	33 ± 11	37 ± 12	0.184
Female sex, n (%)	34 (75.6)	12 (41.4)	0.003
Antrophometric data			
Body mass index (kg/m^2)	22.5 ± 1.9	26.9 ± 2.1	<0.001
Body fat percentage (%)	23.0 ± 7.1	25.4 ± 8.4	0.269
Waist circumference (cm)	74.4 ± 6.7	87.8 ± 9.7	<0.001

Waist-hip ratio	0.8 ± 0.1	0.8 ± 0.1	0.001
Flexibility, muscle strength and endurance			
Iliopsoas shortening, n (%)	21 (47)	23 (79)	0.009
Hamstrings shortening, n (%)	27 (60)	24 (83)	0.068
Gastrocnemius shortening, n (%)	8 (18)	11 (38)	0.068
Quadriceps shortening, n (%)	18 40)	17 (59)	0.163
Piriformis shortening, n (%)	7 (16)	14 (48)	0.003
Pectoral shortening, n (%)	4 (9)	16 (55)	<0.001
Handgrip strength (kgf)	35.6 ± 9.6	42.6 ± 16.0	0.099
Abdominal endurance (repetitions)	45.7 ± 14.9	42.7 ± 12.6	0.47
Clinical data			
Heart rate at rest (bpm)	80 ± 13	75 ± 16	0.207
Systolic blood pressure (mmHg)	110 (110 – 120)	120 (110 – 120)	0.119
Diastolic blood pressure (mmHg)	70 (70 – 80)	70 (70 – 80)	0.471
Exercise testing			
Peak heart rate (bpm)	180 (160 – 189)	176 (132 – 186)	0.623
Percentage of maximal heart rate achieved (%)	93 ± 7	93 ± 11	0.197
VO_{2peak} (ml.kg.min)	48.7 ± 12.0	40.8 ± 11.3	0.012
Heart rate recovery (bpm)	30 ± 13	29 ± 12	0.806

Table 1: Characteristics of the volunteers (n=74).

Predictors of functional capacity in overweight individuals

In the overweight group, the univariate analysis demonstrated the association between VO_{2peak} and sex (p=0.006), BMI (p=0.029), body fat percentage (p<0.001), heart rate at rest (p=0.041) and handgrip strength (p=0.001), as demonstrated in Table 2. All those variables were included in the multivariate model.

Variables	Beta	r	p-value
Sex	11.661	0.514	0.006
Age	-0.208	0.238	0.232
BMI	-1.226	0.42	0.029
Body fat percentage	-1.113	0.819	<0.001
Waist circumference	-0.287	0.246	0.216
Waist-hip ratio	21.803	0.14	0.485
HR at rest	-0.283	0.397	0.041
SBP at rest	-0.105	0.096	0.633
DBP at rest	-0.3	0.267	0.179
Handgrip strength	0.378	0.603	0.001
Abdominal endurance	0.145	0.16	0.424
Iliopsoas shortening	1.99	0.069	0.731
Hamstrings shortening	0.878	0.031	0.879
Gastrocnemius shortening	-1.435	0.063	0.754
Quadriceps shortening	3.616	0.161	0.421
Piriformis shortening	5.826	0.26	0.19
Pectoral shortening	-5.745	0.256	0.197

Table 2: Univariate association between VO_{2peak} and demographic, clinical and functional variables in the overweight group.

In the final multivariate model, only BMI (p=0.027) and body fat percentage (p<0.001) remained as independent predictors of functional capacity in the overweight population. Both, these variables explained 70% of the variations on VO_{2peak}. The regression model derived from this study to predict functional capacity was VO_{2peak} = 85.161 – (0.747 × BMI) – (0.925 × body fat percentage).

Discussion

The present study verified the functional differences between eutrophic and overweight groups and identified the independent predictors of functional capacity in overweight individuals. The main findings of the present study were: (1) overweight subjects were generally male, with iliopsoas, pectoral and piriformis shortening, and with lower values of VO_{2peak}, (2) BMI and body fat percentage were the only independent predictors of functional capacity in overweight volunteers and (3) VO_{2peak} can be predicted by the model VO_{2peak} = 85.161 – (0.747 x BMI) – (0.925 × body fat percentage). Our results can help physiotherapists in the management of overweight people, aiming to prevent musculoskeletal and functional dysfunctions that may compromise the functional capacity of these individuals.

Many studies related to obesity refer to mortality and do not address the functional capacity and health-related quality of life [9,10]. To date, studies are not addressed to overweight individuals, although this population also exhibit higher adverse events in long-term [7,8]. Our findings highlight that, even though they are in a lower risk zone than obese subjects, overweight individuals show anthropometric, musculoskeletal, and functional changes that should be treated by physiotherapists. Physiotherapeutic management of these alterations, such as muscle shortening and functional impairment, can aid in the prevention of muscle injuries, increase adherence in exercise training and prevent the progression of obesity. Additionally, being a parameter of great clinical meaning, we provide an equation to predict the VO_{2peak} in overweight people. The model has a good performance to predict VO_{2peak} without additional information and has potential value in the assessment of functional capacity in these individuals, especially in situations where the maximum test cannot be performed, such as in severe osteoarthritis.

The higher prevalence of muscle shortening may have contributed to the reduction in functional capacity in this population. This fact can be partially explained by the muscle length-tension curve. The muscle has an optimal length to generate maximum tension. As it is stretched or shortened beyond the optimal zone, the muscle progressively loses its ability to generate force [20-22]. Furthermore, many studies have already shown that increasing fat mass reduces exercise capacity [23-25].

Goran et al. [26] showed that fat mass does not have any effect on VO_{2peak} and that those conditions should be considered independent entities. Controversially, the present study demonstrated that, despite all the musculoskeletal, anthropometric and functional differences, BMI and body fat mass were the independent predictors of the functional capacity in overweight individuals.

We believe that studies with a larger sample size should be performed to clarify the issue. For a while, strategies for improving musculoskeletal function seem to be necessary, but it is mandatory to reduce fat mass and body weight to improve functional capacity in this population. High-intensity interval training, for example, seems to be effective to improve cardiorespiratory fitness, reduce metabolic risk factors, and optimize weight loss in overweight/obese populations [27].

Finally, we provide a model for predicting VO_{2peak} in overweight people. The equation showed good performance in the prediction of VO_{2peak}, explaining 70% in the variations of the functional capacity. The formula $VO_{2peak} = 85.161 - (0.747 \times BMI) - (0.925 \times \text{body fat percentage})$ can be applied in areas or situations where the maximum exercise testing is not available.

Conclusion

In the present study, overweight individuals showed iliopsoas, pectoral and piriformis shortening and lower values of VO_{2peak} when compared to eutrophic ones. Furthermore, we provide a model for predicting VO_{2peak} in overweight people by the formula $VO_{2peak} = 85.161 - (0.747 \times BMI) - (0.925 \times \text{body fat percentage})$. Preventive strategies should be adopted in reducing muscle shortening, functional impairment and, mainly, BMI and body fat percentage, since these variables proved to be the independent predictors of functional capacity in this population.

Longitudinal studies are needed to verify whether preventive physiotherapy management in muscle shortening and functional impairment in overweight individuals is effective in reducing the progression of obesity. In addition, the importance of validation of the proposed model for prediction of VO_{2peak} in overweight people is also highlighted.

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