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Evolution of respiratory muscle strength in post-operative gastroplasty

Evolução da força muscular respiratória no período pós-operatório de gastroplastia redutora

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Abstract

Background: Obesity is a worldwide health problem that may also induce respiratory dysfunction. Literature linking weight loss and maximum respiratory pressures is inconclusive. **Objective:** To evaluate longitudinally the maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) of morbidly obese individuals before and after gastric bypass surgery, and to compare them to a control group matched by sex and age. **Methods:** A vacuum manometer (GeRar®, SP, Brazil) was used to assess the MIP and MEP of 30 morbidly obese participants (24 women), aged 32±8 years and with body mass index (BMI) of 43±4 kg/m^2, both before and then one and six months after gastric bypass surgery. After an average of 36 months, 17 patients were reevaluated. A control group of 30 individuals with normal lung function (aged 30±8 with a BMI of 22±2 kg/m^2) was also studied. An unpaired *t*-test and ANOVA for repeated measures were used for statistical analysis, with $p<0.05$ considered as significant. **Results:** No significant differences were observed in the baseline evaluation between the two groups. A significant increase was found in MIP after approximately 36 months of surgery in the obese group. A significant decrease in MEP was observed after one month, as well as a significant increase after 36 months compared with one and six months post-surgery. **Conclusion:** The data showed a significant long-term increase in MIP, as well as a significant decrease in MEP after one month followed by a return to pre-operative values, which indicates that gastric bypass surgery has a positive influence on the strength of inspiratory muscles.

Keywords: maximum respiratory pressures; assessment; physical therapy; gastroplasty; post-operative; respiratory muscle strength.

Resumo

Contextualização: A obesidade é um problema de saúde em todo o mundo e pode causar disfunção respiratória. A literatura que associa a perda de peso corporal às pressões respiratórias máximas (PRM) é inconclusiva. **Objetivo:** Avaliar, longitudinalmente, a pressão inspiratória máxima (PImáx) e a pressão expiratória máxima (PEmáx) de pacientes com obesidade mórbida antes e após gastroplastia redutora e compará-los a um grupo controle pareado por sexo e idade. **Método:** Um manovacuômetro (GeRar®, SP, Brasil) foi utilizado para avaliar PImáx e PEmáx de 30 participantes obesos (24 mulheres e seis homens, 32±8 anos), com índice de massa corporal (IMC) de 43±4 kg/m^2, antes da gastroplastia redutora e após um e seis meses. Após 36 meses, em média, foram reavaliados 17 obesos. Como grupo controle, foram avaliados 30 indivíduos com função pulmonar normal, 30±8 anos, e IMC de 22±2 kg/m^2. Para análise estatística, utilizou-se teste *t* de *Student* para grupos independentes e ANOVA para medidas repetidas. Um p<0,05 foi considerado significativo. **Resultados:** Não foram observadas diferenças significativas na avaliação inicial entre os dois grupos. Houve aumento significativo após 36 meses de cirurgia no grupo com obesidade em relação à PImáx. Em relação à PEmáx, houve diminuição significativa após um mês e aumento significativo após 36 meses, quando comparada com um e seis meses de cirurgia. **Conclusões:** Os dados demonstraram aumento significativo da PImáx em longo prazo, bem como redução significativa da PEmáx após um mês, seguido de um retorno aos valores de pré-operatório, indicando influência positiva da gastroplastia redutora sobre a força dos músculos inspiratórios.

Palavras-chave: pressões respiratórias máximas; avaliação respiratória; fisioterapia; gastroplastia redutora; pós-operatório; força muscular respiratória.

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Introduction

Obesity is a chronic disease characterized by an excessive accumulation of body fat and is probably the oldest metabolic disorder[1]. It is not a single disorder; it is a heterogeneous group of conditions with multiple causes that reflects the interaction between metabolic, dietary, social, cultural and behavioral factors, as well as genetic predisposition[2,3].

An increased deposition of fat results in progressive changes in lung function, causing a reduction in thoracic compliance, lung volumes and lung capacities, especially in expiratory reserve volume and functional residual capacity[4-8]. Respiratory dysfunction in obese patients can occur due to changes in the relationship between lung, chest wall and diaphragm, causing an impairment of respiratory mechanics and abnormalities in gas exchange[3]. It is believed that these changes cause overload in the the respiratory muscle system due to displacement of the increased chest lining mass by the intercostal muscles and an increased resistance to the contraction of the diaphragm muscle by the pressure of an distended abdomen[3,9].

Given the various changes and complications obesity causes, and in light of the benefits of reducing body mass index (BMI), the need to control weight and treat obesity goes without saying[10]. Studies have shown improvements in lung function, sensation of dyspnea, physical capacity and general state of health after weight loss[8,11-14].

Respiratory muscle strength evaluation is a tool used by physical therapists when treating patients with acute or chronic respiratory disorders, both for patient characterization and to evaluate the response to physical therapy interventions[15-17]. Domingos-Benício et al.[18] studied the influence of body weight on respiratory muscle strength in 46 subjects (20-40 years old) who were divided into five groups according to BMI, including an obese group. The maximum inspiratory and expiratory pressures observed were within the normal range according to the values predicted by Black and Hyatt[19]. However, there were no comparisons with predicted values for the Brazilian population.

Paisani, Chiavegato and Faresin[6] studied morbidly obese young adults in the immediate post-operative period (1st and 3rd days after gastroplasty) and observed a significant decrease in maximal respiratory pressures. However, it was not reported whether the values remained within normal range. Weiner et al.[8] evaluated 21 patients before and six months after bariatric surgery, noting an increase in maximal inspiratory pressure (MIP), maximal expiratory pressure (MEP) and respiratory muscle endurance in relation to the pre-operative period.

The effects of gastroplasty on respiratory muscle strength have been investigated over periods ranging from three days to a maximum of six months[6,8]. However, Brolin[20] reported that these patients may continue to lose weight three to five years after surgery.

With the latter observation in mind, the aim of this study was to evaluate maximal respiratory pressures (MRP) in obese patients both before and one, six and approximately 36 months after gastroplasty, as well as to compare them to a control group of eutrophic individuals, allowing a longitudinal evaluation of the evolution of muscle strength, which to our knowledge has not been undertaken.

Methods

Subjects

Nine patients with class II obesity and 22 patients with class III obesity (25 women) were selected for this study. One subject was excluded due to complications during anesthesia that resulted in the interruption of the surgery. Thus, 30 participants were studied. Patients were selected from a list of those scheduled for gastroplasty. The evaluated subjects underwent Fobbi-Capella technique stomach reduction surgery by the same surgeon. For the control group, 30 subjects with normal BMIs, matched by sex and age, were selected.

Inclusion criteria for the obese group were: severe obesity (BMI between 35.0 and 39.9 kg/m^2); estimated gastroplasty with the Fobbi-Capella technique within seven days; age between 18 and 60 years; no history of cardiopulmonary diseases; written informed consent. Control group inclusion criteria were: age between 18 and 60 years; BMI between 18 kg/m^2 and 29.9 kg/m^2; spirometry exam indicating no respiratory disorders of any kind; no history of cardiopulmonary diseases; nonsmokers or ex-smokers, no history of prior abdominal surgery; written informed consent. The obese group exclusion criterion was the presence of pre-operative and/or post-operative complications that required more than 24 hours on mechanical ventilation. Failure to comply with the study protocol was an exclusion criterion for both groups. The study was approved by the Ethics Committee of the Universidade Federal de Minas Gerais (UFMG), Belo Horizonte, MG, Brazil (Report # ETIC 123/05).

Instruments and measures

Maximal respiratory pressures

The equations proposed for the Brazilian population by Simões et al.[21] were used as reference values.

Body mass index

Obese group anthropometric data was measured in the physician's office, while control group data was measured in the research laboratory. Height and weight were measured with calibrated scales (Filizola Ind. Ltda, São Paulo, Brazil and Balmak BK 300 FA, São Paulo, Brazil, respectively). From these data, the BMI was calculated.

Spirometry

A Vitalograph 2120 spirometer (Vitalograph, Ennis, Ireland) was used to perform the pulmonary function test. Forced vital capacity (FVC) maneuvers were performed to measure lung volumes and flows. The maneuvers followed ATS/ERS criteria for acceptability and reproducibility and quality[22]. The results were compared to predicted values for the Brazilian population[23].

Procedures

All subjects were initially instructed to read and sign the informed consent form and fill out an identification form, after which anthropometric and spirometric data were measured.

A single researcher carried out all MRP measurements according to well-established protocols described in the literature[24-26].

Assessment of obese subjects was performed preoperatively and again one, six and approximately 36 months after surgery. The control group was evaluated only once.

The physical therapy follow-up of these patients was intended to reduce pulmonary complications and prevent deep vein thrombosis and consisted of pulmonary expansion techniques (e.g. diaphragmatic exercises and incentive spirometry) early mobilization and ambulation on the first day after surgery, active kinesiotherapy of the upper and lower limbs and bronchial hygiene techniques, when necessary. All obese group patients remained hospitalized for three days and did not develop complications.

Statistical analysis

After a pilot study was carried out, the sample size calculation indicated that five participants would be necessary in each condition for the two dependent variables for a power of 80% and a significance level of 0.05. The Shapiro-Wilk test was used to test each variable for normality. Descriptive analysis, shown as mean and standard deviation, was performed for sample characteristic variables: age, body weight, height, BMI, peripheral oxygen saturation (SpO_2), heart rate and spirometric measurements. Student's *t*-test for independent groups or the Mann-Whitney U test were used to compare these variables and the dependent variables between the group of obese patients in the pre-operative state and the control group, depending on the normality or non-normality of data distribution. To compare the obese group at different times (pre-operatively and after one, six and approximately 36 months after surgery), repeated-measures ANOVA was used. Considering that only the MEP data after six months of surgery was non-normally distributed (one of a set of four measurements) ANOVA was chosen. The correlation between weight loss in kg after ~36 months and MRP values (Pearson or Spearman, depending on the data distribution) was carried out. In all tests, $p<0.05$ was considered significant. Statistical Package for Social Sciences (SPSS, Chicago, IL, USA, Version 13.0) was used to prepare the database and for statistical analysis.

Results

Initially, 30 individuals were assessed in each group. All patients underwent the Fobbi-Capella or Y-Roux surgical technique with combined (general and epidural) anesthesia. One and six months after surgery, 28 and 24 subjects, respectively, were assessed due to the inability of some to perform the MRP measurement tests. After approximately three years, 17 participants were reassessed. Sample losses were due to the following reasons: acute myocardial infarction (n=1), pregnancy (n=1), moving to another state (n=1), failure to contact due to change of address or telephone (n=3) and refusal to participate in follow-up (n=7).

There was a variation of up to four days for the one and six month post-surgery assessments. The average time was 39±4 months for the final assessment.

Table 1 shows the demographic, anthropometric and spirometric data of the two groups studied. There were no significant differences regarding age, gender, height, heart rate or SpO_2. The weight and BMI values of the obese participants were significantly higher than those of the control group. Three volunteers in the obese group had mild obstructive respiratory disease, one presented a mild restrictive respiratory disease, and 26 had normal spirometry. Eleven volunteers in the obese group presented comorbidities: hypertension (n=5), low back pain (n=1), dyslipidemia (n=1), disc herniation (n=1), work-related orthopedic disease (n=1), knee cyst (n=1) and bipolar disorder (n=1). Three individuals were ex-smokers and the others were nonsmokers.

All ex-smokers showed spirometry values within normal limits. The FVC and forced expiratory volume in one second (FEV_1) were significantly higher in the obese group than the control group, but both had predicted values within normal limits. All obese participants were sedentary, while five subjects in the control group had regular physical activity.

The obese group progressively lost weight after surgery. On average, there was a reduction of 34.52±7.70% (19.62 to 49.22) of body weight after 36 months.

Table 2 shows the MRP results. There were no significant differences in MIP and MEP between the obese (pre-operative) and control groups (p=0.377 and p=0.807, respectively). There was a significant increase in MIP in obese subjects 36 months post-surgery in relation to the three previous occasions (preoperatively, one month and six months). There was no significant difference between the pre-operative value and that of either one month or six month post-surgery, or between the one and six month post-surgery values. The obese group MEP values significantly decreased one month post-surgery compared to pre-operative values and significantly increased after 36 months compared to one and six months post-surgery.

The observed correlation between MIP and weight loss at the time of last measurement (~36 months) was non-significant and of low magnitude (p=0.148, r=0.378 with a power of 0.32). The MEP results were similar, with a non-significant correlation of very low magnitude (p=0.814, r=0.064 with a power of 0.06).

Regarding MIP values below the lower limit of normality, the following percentages were observed: 5.88% pre-operative, 11.76% one month post-surgery, 5.88% 6 months post-surgery and 5.88% 36 months post-surgery. No obese group MEP value was below the lower limit of normality in any evaluated period.

Discussion

The main results of this study were: 1) When followed up after approximately three years, a significant increase in MIP was observed in relation to pre-operative and one and six month post-operative values; 2) MEP values were significantly reduced one month after surgery and, compared to one and six months post-surgery, had significantly increased after 36 months; 3) There was no significant difference in MIP or MEP among obese subjects and eutrophic subjects.

To our knowledge, only one study in the literature has investigated the effect of gastroplasty on MRP beyond the immediate post-operative period. Weiner et al.[8] reported an

Table 1. Demographic, anthropometric and spirometric data of 30 participants with obesity (pre-operative) and control group.

Variables	Group with obesity (n=30)	Control Group (n=30)	p
Sex	24 women: 6 men	24 women 6 men	-
Age (years)	32.37±8.5	30.60±7.76	0.405
Height (m)	1.67±0.11	1.67±0.10	0.97
Weight (kg)	120.13±24.32	62.11±11.68	0.001*
BMI (kg/m^2)	42.72±4.10	21.99±2.22	0.001*
HR (bpm)	74.73±11.77	70.97±9.10	0.171
SpO_2 (%)	96.36±1.35	96.87±1.38	0.185
FEV_1 (% pred)	117.47±29.99	95.89±9.09	0.005*
FVC (% pred)	119.12±34.18	97.93±9.36	0.045*
$FEF_{25-75\%}$ (% pred)	124.40±42.55	88.78±25.42	0.001*

Data presented as mean±standard deviation. BMI=body mass index; HR=heart rate; SpO2=saturation of hemoglobin in oxygen; FEV_1=forced expiratory volume in one second; FVC=forced vital capacity; FEF_{25-75}%=forced expiratory flow between 25 and 75% of forced vital capacity. % pred refers to the percentage of predicted for the Brazilian population. *p<0.05 using Student´s t test for independent groups (age, height, weight, BMI, HR and $FEF_{25-75\%}$) and Mann-Whitney U (SpO_2, FEV_1 and FVC) according to the data distribution.

Table 2. Maximum respiratory pressures of participants with obesity before (pre-operative) and after one, six and approximately 36 months of gastroplasty and participants of control group.

Variables	Control Group (n= 30)	Pre-operative (n= 30)	After 1 month (n=28)	After 6 months (n=24)	After 36 months (n=17)	F	p
MIP (cmH_2O)	106±46	96±35	100±38	104±33	121±35*	8.145	0.005
MEP (cmH_2O)	108±32	107±37	98±31$^{\#}$	99±30	119±38$^{\&}$	3.844	0.017

Data presented as mean±standard deviation. MIP=maximal inspiratory pressure; MEP=maximal expiratory pressure. *p<0.05 compared with pre-operative, one month and six months (for MIP), $^{\#}$p<0.05 compared with pre-operative, $^{\&}$p<0.05 compared with one month and six months (for MEP), using ANOVA for repeated measures.

increase of MRP values six months after surgery compared to pre-operative values in a group of 21 obese patients, which was not observed in our results. Subject BMI (on average, about 40 kg/m^2) as well as age (25-52 in the study by Weiner et al.[8] versus 19-59 in the present study) can be considered similar in both studies. However, Weiner et al.[8] did not describe the gender composition of their sample. In the present study, the majority of patients were women, and it is known that there is a relationship between respiratory muscle strength and gender. Thus, if their sample was primarily men, the differences in results between the studies may be explained.

The decrease in MEP observed after one month of surgery may be related to pain in the post-operative period, the presence of a supraumbilical scar and the abdominal muscle section. However, this parameter was not evaluated and may be considered a study limitation.

Studies evaluating these indices of respiratory muscle strength in obese individuals and comparing them with data from eutrophic individuals or normative values have shown no consistent results[3,4,6,7,18,27,28].

Kelly et al.[27] found no significant difference in MIP and MEP values among obese individuals (with an average of 183% of the predicted weight) and individuals with an average of 99% of predicted weight, despite a tendency toward lower values among the former. Domingos-Benício et al.[18], in assessing young adults with different BMI, including obese individuals, demonstrated that the MRP were within normality limits according to data provided by Black and Hyatt[19]. Sarikaya et al.[7] observed significantly reduced MIP and MEP with no significant difference when comparing a group of 51 obese individuals (16 class I, 20 class II and 15 class III) with 44 eutrophic individuals. There was no significant difference between the degrees of obesity.

A study by Paisani et al.[6] also demonstrated that the mean values of respiratory muscle strength indices in obese individuals were within the limits of normality described by Neder et al.[24], despite the great variability observed in individual measures. the percentage of individuals showing values below the lower limit of normality was not reported. It should be noted that in the present study the prediction equations recently proposed by Simões et al.[21] for the Brazilian population were used as reference. Our data also showed that only some of the obese participants had MIP values below the lower limit of normality[21]; no MEP value below the lower limits of normality was observed. However, if we compare these values with those predicted by Neder et al.[24], the percentage of participants with values below the lower limit of normality was over 50% for both MIP and MEP in the pre-operative and over 10% after 36 months of surgery. This could support the argument that the recently proposed values better reflect the respiratory muscle strength of the Brazilian population.

Obesity overloads the respiratory system, increasing the mechanical work involved in breathing due to the increased deposition of fat in the chest wall, which increases the mass to be moved during breaths, as well as to elevation of the diaphragm, which, upon contracting, acts under the pressure of a distended abdomen[6,9,18]. This overload can trigger an increase in the activity of respiratory muscles and have a long-term training effect that can increase respiratory muscle strength[3,6,18]. Moreover, it is believed that this strength decreases when these individuals develop hypoventilation syndrome, which is characteristic of severe obesity[3]. Post-gastroplasty weight reduction may promote an improvement in respiratory mechanics and compliance, improving the efficiency of the respiratory muscles[8]. The correlations found in the present study between the MRP and long-term weight loss were of low magnitude and non-significant. However, since the statistical analysis included a low number of patients due to sample loss, which is common in longitudinal studies, the power analysis also showed low values (32% and 6%, respectively). Thus, the small number of subjects studied may have affected the results, increasing the possibility of a type II error[29].

A limitation of this study was the inability to perform the follow-up with a larger number of patients. However, an attempt was made to contact the 30 patients, and all those found who were willing to continue participating in the study were evaluated. Moreover, pain, which can compromise an individual's performance during MEP measurement, was not assessed after one month, and hence, it is not possible to exclude its influence on the observed decrease.

In conclusion, a significant increase in the MIP values of obese subjects was observed after a mean time of approximately 36 months post-surgery. The significant reduction of MEP in obese subjects one month after surgery, which may be related to dysfunction of the abdominal muscles due to the incision in the supraumbilical region[30], was followed by gradual increase until 36 months and did not exceed pre-operative period values.

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