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Short-Term Effects of Weight Loss after Bariatric Surgery on Respiratory and Skeletal Muscles' Strength

Abdolreza Mehdinavaz[1], Khosrow Najjari[2,3], Mohammad Talebpour[2,3], Hossein Zabihi-Mahmoudabadi[2,3], Mastaneh Rajabian Tabesh[4], Fezzeh Elyasinia[5], Farhad Kor[6], Mohammad Reza Fattahi[2] and Maryam Abolhasani[4]*

1. Department of Surgery, Tabriz University of Medical Sciences, Tabriz, Iran
2. Department of Surgery, Sina Hospital, Tehran University of Medical Sciences, Tehran, Iran
3. Minimally Invasive Surgery Research Center, Sina Hospital, Tehran University of Medical Sciences, Tehran, Iran
4. Cardiac Primary Prevention Research Centre, Tehran Heart Centre, Tehran University of Medical Sciences, Tehran, Iran
5. Department of Surgery, Shariati Hospital, Tehran University of Medical Sciences, Tehran, Iran
6. Department of Surgery, Golestan University of Medical Sciences, Gorgan, Iran

*** Corresponding author**

Maryam Abolhasani, MD
Cardiac Primary Prevention Research Centre, Tehran Heart Centre, Tehran University of Medical Sciences, Tehran, Iran
Tel: +98 912 6192 528
Email: dr_m_abolhasani@yahoo.com

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Abstract

Background: Bariatric surgery leads to weight loss and body fat percentage reduction, but patients are prone to lean tissue loss which itself reduces the quality of life, and increases the risk of deatand h. This study evaluated the effects of bariatric surgery and changes in Fat Mass (FM) and Fat-Free Mass (FFM) on the respiratory and skeletal muscles' strength three months after bariatric surgery.

Methods: After obtaining demographic information, anthropometric measurements and body composition analysis, including Body Mass Index (BMI), FM, FFM, Percent Body Fat (PBF), handgrip isometric force, respiratory muscle forces and spirometry volumes, were assessed before and three months after bariatric surgery in 50 men and women undergoing this surgery.

Results: Weight, BMI, FM, PBF and FFM isometric muscle force were decreased significantly. In contrast, respiratory muscle forces and respiratory volumes were increased significantly three months after the surgery. Reduction in FFM 3 months after the surgery did not lead to a change in respiratory muscle strength (p-values$\geq$0.05).

Conclusion: According to our findings, FM and FFM along with weight and BMI decrease significantly after bariatric surgery. These alternations were accompanied by a significant increase in respiratory muscle strength but were not correlated with handgrip muscle force changes.

Keywords: Bariatric surgery, Fat mass, Obesity, Respiratory muscles

Introduction

According to the World Health Organization, obesity has tripled since 1975, and in 2016 the number of overweight and obese adults worldwide reached over 2 billion.[1] With the overall increase in obesity in the world, the number of people with morbid obesity has also grown significantly in developing and developed countries (2,3). According to the National Survey on Health and Nutrition (NHANES) in 2013-2014, one in 13 adults in the United States was morbidly obese (2,4). There is strong evidence that non-surgical treatments are inadequate among patients with morbid obesity, while bariatric surgery as an invasive procedure has good long-term results in treating these individuals including significant weight loss, reduction of comorbidities and increased quality of life (5,6). Bariatric surgery leads to weight loss and a reduction in Body Fat Percentage (BFP), but patients are also prone to lean tissue loss (7-9), which in itself reduces the quality of life, reduces physiological health, and increases the risk of death (10-16). On the other hand, it is essential to note that people with morbid obesity have lower skeletal muscle quality compared to normal-weight people and have lower functional capacity, thus maintaining Fat-Free Mass (FFM) and skeletal muscle mass is very important in people undergoing bariatric surgery (17-21). Muscle strength is an essential aspect of functional capacity. For example, quadriceps muscle strength is associated with walking speed, climbing stairs, getting up from a sitting position, stability, and even risk of falling. Therefore, with a decrease in muscle strength such as quadriceps or upper limb muscle strength, daily activities are disrupted (22). On the other hand, obesity not only impairs skeletal muscle function but also leads to changes in pulmonary volume and respiratory muscle strength and generally impairs lung function (23-27). In recent years, the effect of bariatric surgery on pulmonary function and respiratory muscle strength has been considered. Previous studies have shown an association between significant postoperative weight loss with improved pulmonary function indices, including Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), alveolar-capillary diffusion capacity and retention of carbon dioxide (CO_2) and also improved respiratory rate (28-31). Therefore, this study aimed to evaluate the effect of bariatric surgery and changes in adipose tissue and muscle tissue on the strength of respiratory and skeletal muscles three months after bariatric surgery.

Materials and Methods

This quasi-experimental study was performed on 50 candidates for bariatric surgery in the obesity clinic in a university hospital. Participants entered the study after obtaining informed consent.

Inclusion criteria were men and women with a Body Mass Index (BMI) ≥ 40 *kg/m²*, the age range of 18-65 years, no history of diabetes and cardiovascular disease, neurological and musculoskeletal disorders, no use of psychological drugs and corticosteroids in a recent month and no history of surgery on the musculoskeletal or cardiopulmonary system. These histories can affects muscle strength.

After obtaining demographic information, anthropometric measurements (weight, height, and BMI) were assessed. Body composition analysis, including Fat Mass (FM), FFM, BFP, and muscle mass was performed by body analyzer BC-418 MA (TANITA, Tokyo, Japan).

The isometric strength of the hand muscles was measured by a YAGAMI YDM-110 Dg hand dynamometer. Muscle strength on dominant and non-dominant hands was measured three times, and the highest strength was recorded for each volunteer. Respiratory strength was assessed using a spirometer for lung volumes and a GANSHORN body plethysmograph PowerCube Body+ to measure the strength of the inspiratory and expiratory muscles using the variables PImax (maximum inspiratory muscle pressure) and PEmax (maximal expiratory muscle pressure).

Assessments were performed before and three months after the surgery, following a loss of at least 30 to 50% of Excess Weight Loss (EWL). Throughout the study, participants were on the same diet in terms of calorie and protein intake. They were placed on a high protein standard diet by a nutritionist (600-800 *kcal* for the first four weeks after surgery, 8001000-*kcal* for the second four weeks and 1000 to 1200 *kcal* for the third four weeks) (32). Physical activity and dietary supplements were determined based on a valid guideline for all participants (33). All the steps were performed under the supervision of a physician specializing in this field.

Continuous variables were presented as mean ± standard deviation (SD). Categorical variables were presented as the frequency with percentages. The one-sample Kolmogorov-Smirnov test was used to test each variable for normality. Paired samples t-test or the Mann–Whitney U test was utilized to compare the respiratory values including, FEV1, FVC, FEV1/FVC, Total Lung Capacity (TLC), Residual Volume (RV), maximal inspiratory mouth pressures (PI max), and maximal expiratory mouth pressures (PE max) before and 3 months after the surgery, depending on the normality or non-normality of the data distribution. The same assessment was done for preoperative and postoperative weight, BMI, FM, FFM and BFP. In all the tests, values of $p<0.05$ were considered statistically significant. Statistical Package for Social Sciences (SPSS Version 26.0. Armonk, NY: IBM Corp) was used to prepare the database and statistical analysis.

Results

All 50 patients completed the 3-months follow-up and were all available for the final analysis. The majority of the included patients were female (n=42; 84%). The mean age was 39±9.1 years, mean height was 161.8±81 *cm* and mean BMI was 43.7±3.8 kg/m^2. More than half of the patients underwent sleeve gastrectomy (n=37; 74%), and the rest received a one-anastomosis gastric bypass (n=13; 26%). The surgical intervention resulted in a weight loss of 205.9± *kg* (40.8±7.2% EWL) at three months postoperative. No complications were seen postoperatively.

As shown in table 1, weight, BMI, FM, PBF , FFM and isometric muscle force were decreased significantly while respiratory muscle forces and respiratory volumes were increased significantly three months after surgery.

As shown in table 2, there was no relation between decreasing in FM and PBF and respiratory muscle strength (p-values ≥0.05). Moreover, determining the relationship between FM reduction and isometric strength of the dominant hand, no significant change was observed (p-values ≥0.05). On the other hand, the decrease in FFM three months after the surgery did not lead to a change in respiratory muscle strength (p-values ≥0.05).

Comparison of the effect of FFM reduction and isometric strength of the dominant hand, before and three months after surgery, showed no significant relationship in this regard (p-values ≥0.05). In

Table1. differences between weight, BMI, FM, PBF*, FFM, respiratory muscle forces and isometric muscle forces before and after surgery

Variables	Pre bariatric surgery		Post bariatric surgery		p-Value
	Mean	Standard Deviation	Mean	Standard Deviation	
Weight	115.1	13.5	95.1	11.3	≤ 001
BMI*	44.0	4.0	36.3	3.0	≤ 001
Fat mass(*kg*)	53.2	9.1	39.7	7.0	≤ 001
Fat mass (%)	46.3	5.3	38.1	5.7	≤ 001
Fat free mass (*kg*)	61.6	10.2	55.2	9.5	≤ 001
PI maximum**	44.7	14.2	48.5	14.6	≤ 001
PE maximum***	65.7	18.0	71.7	19.2	≤ 001
FEV1****	2.7	0.8	2.9	0.8	≤ 001
FVC*****	4.9	12.3	3.3	1.0	≤ 001
FEV1/FVC	85.3	4.1	87.2	3.4	≤ 001
TLC#	4.5	0.9	5.9	8.1	≤ 001
RV##	1.7	0.5	1.9	0.6	≤ 001
Isometric muscle Force	28.1	7.3	26.9	6.9	0.006

PBF*: Percent body fat
BMI**: Body Mass Index
PI max***: Maximal inspiratory mouth pressures
PE max****: Maximal expiratory mouth pressures
FEV1*****: Forced Expiratory Volume
FVC******: Forced Vital Capacity
TLC#: Total Lung Capacity
RV##: Residual Volume

Table 2. Correlations between fat mass, fat free mass, weight loss and BMI changes after 3 months of bariatric surgery with respiratory muscle forces and isometric muscle forces

Variables	PI max 3 m Post Op			PE max 3 m Post Op			Isometric muscle force 3 m Post Op		
	B	Std. Error	sig	B	Std. Error	sig	B	Std. Error	sig
Fat mass decreased (*kg*)	0.270	0.442	0.544	0.452	0.580	0.440	0.043	0.156	0.785
Fat Free Mass decreased (*kg*)	1.215	0.684	0.083	0.779	0.925	0.404	0.218	0.250	0.804
Fat mass decreased (%)	0.270	0.442	0.544	0.452	0.580	0.440	0.042	0.150	0.780
Weight loss decreased (%)	0.378	0.302	0.218	0.548	0.397	0.174	0.172	0.105	0.107
BMI decreased	0.128	1.011	0.900	0.504	1.329	0.706	0.042	0.352	0.905

BMI, body mass index; PI max, maximal inspiratory mouth pressures; PE max, maximal inspiratory mouth pressures; sig, significancy; Std., Standard.

addition, our results indicated no significant relationship between respiratory muscle strength and isometric hand strength (p-values ≥0.05).

Although BMI changes before and three months after surgery were significant, no correlation was found between changes in BMI and respiratory muscle strength and isometric strength of the dominant hand (p-values ≥0.05). Also, there were no significant changes between changes in FM, FFM, EWL and BMI with spirometry indexes.

Discussion

This study was a quasi-experimental study to investigate the effect of bariatric surgery and changes in FM and FFM on the strength of respiratory and skeletal muscles three months after surgery, and 50 people were included in this study. As expected, and in line with the results of the previous studies,[34-39] the participants lost weight significantly three months after the bariatric surgery (EWL of 40.8±7.2%). Our findings showed no significant correlation between EWL, FM, and FFM reduction with the increase in respiratory muscle force and reduction in isometric handgrip muscle force, 3-month post-bariatric surgery.

In a study by Nuijten *et al*, data analysis of 3,596 patients undergoing bariatric surgery indicated that, on average, 21% of the weight loss three months after surgery was due to lean tissue loss.[36] Also, the results of this study have shown that the highest rate of lean tissue loss after bariatric surgery occurs in the first 3-6 months after surgery, which is in line with the results of the previous studies (37-39). Another study found that patients who underwent sleeve gastrectomy lost 10% of their lean tissue in the first month, and this number rose to 17% by the end of 12 months after surgery.[40, 41]

Muscle mass is the main part of fat oxidation, and previous studies have shown that low muscle mass and high FM can lead to less weight loss following bariatric surgery (42,43). However, the relationship between FFM, lean tissue loss and skeletal muscle strength after bariatric surgery is still unclear (17). It seems that reducing skeletal muscles' strength, such as isometric handgrip strength, is due to decreasing in excessive loss of FFM, including lean mass. In a study published in 2019, the reduction in lean mass in patients 12 months after surgery averaged 13±6%, and the mean absolute muscle strength decreased by 9 to 17%, but relative strength improved relatively (17).Their results showed that the strength of the handgrip was significantly lower at 6 and 12 months after the surgery than before the operation, which is in line with the present study results. Previous studies have also shown that absolute muscle strength after surgery is significantly reduced in the lower and upper limbs (44-46).

Due to fat in the chest wall in patients with morbid obesity, respiratory function is reduced. Preliminary studies suggest that respiratory muscles are ineffective in patients with morbid obesity due to decreased chest wall compliance and decreased lung volume (47). On the other hand, patients with morbid obesity have less aerobic capacity than normal-weight people, and physical activity tolerance is lower, so over time, cardiopulmonary fitness in these groups decreases (25,27). Several studies have demonstrated that some lung functions, including FEV1, FVC and gas exchange, improve after bariatric surgery. Studies have also been performed on the strength of the respiratory muscles, which has been contradictory (31).

In the present study, the changes of PI maximum, PE maximum, FEV1, FVC, FEV1 / FVC, TLC and RV were statistically significant compared to before surgery. Previous studies have also considered the effect of bariatric surgery on respiratory muscle strength (28,29,31), which showed a decrease in oxygen consumption, improved pulmonary function and a significant increase in FVC, which is in line with the results of the present study. Also, in the study of Campos *et al*, Expiratory Reserve Volume (ERV) has been shown to increase by 550 *ml* in morbidly obese women subjected to bariatric surgery, which is in line with the results of the previous studies (23). However, a negative relationship between waist circumference reduction and FVC and FEV1 was reported, which was also reported in the study of Wei *et al* (48). Suggested mechanisms for improving pulmonary functions are weight loss and reduction of intra-abdominal pressure due to high fat density in this area. It also seems that significant weight loss following obesity surgery can lead to removing pulmonary ventilation barriers in obese patients.

The limitations of the study were low sample size, the low number of male participants compared to women subjects and short follow-up time. We recommend that the same assessments are done with a large sample size and adding a control group in the long period to determine the effect of significant weight loss and FFM reduction on muscle strength after bariatric surgery.

Conclusion

According to our findings, FM and FFM along with weight and BMI decrease significantly after bariatric surgery. These alternations were accompanied by a significant increase in respiratory muscle strength, but were not correlated with changes in hand grip muscle force.

Ethics Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent to Participate

Informed consent was obtained from all the individual participants included in the study.

Consent for Publication

All authors have read and approved the final version of the manuscript.

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None.

Conflict of Interest

The authors declare no competing interests.

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