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The Impact of Organized Exercise on the Functional Abilities of Individuals with Obesity

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Abstract

The aim of this research was to determine whether there is a difference in the improvement of lung function and reduction in abdominal fat thickness in obese individuals who follow a reduced diet programme and engage in regular organised exercise, compared to those who only follow the diet. This prospective study included 50 obese patients from the Obesity Outpatient Clinic of the Internal Medicine Clinic at Clinical Hospital Center Rijeka. It was conducted from October 2023 to May 2024. All participants followed a reduced diet and were given the option to take part in organised exercise sessions. They were divided into two groups: those who exercised (n=25) and those who did not (n=25). Data on gender, age, weight, height, BMI, waist circumference, abdominal fat thickness, and lung function parameters (FVC, FEV1, VC) were collected at the beginning and end of the intervention. The results showed no statistically significant differences between the two groups in final BMI ($p = 0.154$), waist circumference ($p = 0.382$), abdominal fat thickness ($p = 0.435$), FVC ($p = 0.741$), FEV1 ($p = 0.676$), or VC ($p = 0.892$). However, a statistically significant improvement ($p < 0.001$) was observed in all measured parameters between the first and second measurement for all participants. There was no confirmed difference between those who exercised and those who did not. Nonetheless, significant improvements were observed in all subjects over time.

Keywords: *functional abilities, obesity, organized exercise*

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Introduction

Obesity is a global epidemic and represents a serious health and social problem. The World Health Organisation defines obesity as a condition characterized by a body mass index (BMI) exceeding 30 kg/m². Adipose tissue is a metabolic, immune and endocrine organ, and its excessive accumulation is directly related to an increased risk of developing vascular, pulmonary, endocrinological, musculoskeletal and other diseases. The most common cause of obesity is excessive consumption of foods rich in fat and refined sugar, as well as a lack of physical activity (Ghesmaty Sangachin, Cavuoto, & Wang, 2018).

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In obese individuals, structural changes in the thoraco-abdominal region lead to reduced diaphragmatic mobility and reduced rib movement, which impairs adequate breathing mechanics. Adipose tissue produces a large number of cytokines and bioactive mediators, leading to a condition associated with reduced lung development and an increased risk of developing certain diseases in obese individuals. Ferreira et al. report that adolescents with increased visceral adipose tissue exhibit altered lung function, characterized by an increased forced vital capacity (FVC). They also observed a reduction in forced expiratory volume in the first second (FEV 1) within this population (Ferreira et al., 2022). Excess body mass is associated with significant changes in lung volume and capacity values and altered respiratory mechanics in individuals with increased waist and hip circumference, which are more pronounced in women than in men (Shanmugasundaram, Bade, Sampath, & Talwar, 2023). Obesity has a detrimental effect on respiratory mechanics. This is probably due to compression of the lungs, which causes a decrease in expiratory parameters and leads to a compensatory increase in inspiratory parameters to maintain a constant vital capacity (VC). Impaired respiratory function can lead to broncho-obstruction, i.e. reduced airflow through the airways, and the occurrence of local and systemic hypoxia, which can be the cause of pathological changes in all organ systems (Bhatti, Laghari, & Syed, 2019).

Excessive accumulation of adipose tissue in the abdominal and ches wall regions can impair normal pulmonary function. This leads to a reduction in respiratory volumes, particularly functional residual volume and expiratory reserve volume, due to restricted chest wall motion. The stress caused by obesity reduces the mobility of the chest wall and increases the respiratory rate. One of the main causes of respiratory insufficiency is the pattern of rapid and shallow breathing, which is a predictive factor for the reduction of vital lung capacity. Disorders related to respiratory mechanics lead to an increased need for ventilation. This leads to a weakening of the respiratory muscles, which is a key feature of most diseases that predispose to respiratory insufficiency (Chlif, Keochkerian, Choquet, Vaidie, & Ahmaidi, 2009). Obesity, especially severe and extreme central obesity, impairs the physiology of the respiratory system, both at rest and during physical activity. The reduction of the reserve expiratory volume, the functional residual capacity and the impaired mechanics of the respiratory system lead to a restrictive ventilatory defect. Low functional residual capacity and reduced expiratory reserve volume increase the risk of expiratory flow limitation and airway obstruction during sleep. Consequently, obesity can cause expiratory flow limitation and the development of intrinsic positive end-expiratory pressure, especially in the supine position. This increases the respiratory rate and the strain on the respiratory muscles, leading to dyspnoea. Significantly reduced expiratory reserve volume values can lead to ventilation flow disturbances with airway obstruction in certain lung zones, causing ventilation-perfusion mismatch and gas exchange abnormalities. Obesity can also impair upper airway mechanical function and neuromuscular strength and increase oxygen consumption, which in turn increases the work of breathing and impairs ventilatory drive. The combination of disturbances in respiratory mechanics, excessive production of carbon dioxide and reduced ventilatory surface area in obese individuals may favour the occurrence of hypoventilation syndrome (C.-K. Lin & Lin, 2012).

By normalising the values of the respiratory parameters, respiratory mechanics are improved and ventilatory restriction is alleviated. Improving respiratory volume values improves respiratory function, exercise intolerance and therefore quality of life (Maloča Vuljanko & Petković, 2023). This considerations lead to the aim of our study, which is to compare the values of FVC and FEV1, the values of VC and the thickness of abdominal fat tissue in obese people who exercise regularly with those who do not.

Methods

Study design

The prospective study was conducted over a six-month period, from October 2023 to May 2024, at the Clinical Hospital Centre Rijeka, in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the hospital's Ethics Committee (Ref. No.: 2170-29-02/1-23-2). The study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational research ("STROBE," n.d.).

Setting of the study

The respondents are patients of the Obesity Outpatient Clinic, which operates in the Department of Endocrinology, Diabetes and Metabolic Diseases of the Clinical Hospital Centre Rijeka (KBC). In the obesity outpatient clinic, all patients receive dietary instructions based on an internal examination and individual findings, are advised by a physiotherapist on the importance of physical activity and receive psychological counselling from a psychologist. Participation in organised exercise classes under the expert supervision of a physiotherapist twice a week was voluntary.

Inclusion criteria: BMI over 27 kg/m2, patients registered in the obesity outpatient clinic of Clinical Hospital Center Rijeka in 2023 with a recommendation for organised exercise by a doctor and physiotherapist.

Exclusion criteria: Presence of chronic lung disease, history of pulmonary embolism, history of angina pectoris, history of myocardial infarction, loss of consciousness for any reason in the last 6 months, irregular exercise.

50 male and female subjects from the working population with a diagnosis of obesity were included in the study. The subjects were divided into two groups, the control group (KS) and the experimental group (ES), and there were 25 subjects in each group. The control group consisted of patients who received lifestyle change instructions at the Clinical Hospital Center Rijeka Obesity Clinic in the form of a restrictive diet adapted to medically determined individual needs and were not interested in organised exercise, while the experimental group consisted of patients who, in addition to a restrictive diet, exercised twice a week for 60 minutes.

Outcome Measures

Testing of subjects was carried out twice, before the start of the organised training and after six months of participation in the study for both groups. Body mass and height were measured, on the basis of which BMI was calculated, as well as abdominal fat thickness and waist circumference. The thickness of the abdominal adipose tissue was measured with a calliper and expressed in centimetres. The measurement was taken in a standing position. The examiner lifted the transverse skin fold 2 cm to the side of the navel with his hand, covered it with the tips of the caliper and read the result. In addition to the anthropological measurements, spirometric tests, including forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), and vital capacity (VC), were performed using a portable Spirolab

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Mini Flowmeter device. During the spirometric test, subjects sat on a chair and held the spirometer attachment with their hand, which has a sensor and a disposable mouthpiece. A special clip was attached to the subject's nose to prevent air from escaping from the nose. The test subjects were also instructed to hold the mouthpiece firmly with their lips to prevent the airflow along the mouthpiece from being lost. The subjects were then asked to inhale as much air as possible through the mouthpiece and then blow all the air from the lungs into the mouthpiece of the spirometer in such a way that the exhalation lasts for 6 seconds, which the examiner monitors on the screen. This is followed by two more inhalations and exhalations in continuity in the same manner described, without separating the lips from the mouthpiece at any time (Maloča Vuljanko & Petković, 2023).

Statistical data processing

The programme Statistica 14.0.0.15 (TIBCO Software Inc.) was used for statistical data processing. Nominal variables, gender and group, are given in absolute and relative frequencies and are compared using the chi-square test. Other variables tested in this study are expressed on an interval scale (FVC, FEV1, VC and abdominal adipose tissue thickness) and are also the dependent variables of this study. As the variables were expressed on an interval scale but deviated from the normal distribution, they were described by median, interquartile range (IQR), minimum and maximum values. The Wilcoxon test was performed to investigate whether subjects differed in body mass, body mass index, waist circumference, abdominal fat thickness, forced vital capacity (FVC), forced expiratory volume in the first second (FEV1) and vital capacity (VC) at the first and second measurement in terms of participation in physical activity (NV1 – 1st and 2nd measurement, NV2 – participation or non-participation in physical activity). The Friedman ANOVA was used to analyse the difference between the subjects' parameters at the first and second measurement depending on whether or not they took part in sport (NV1 – 1st and 2nd measurement, NV2 – participation or non-participation in sport). The parameters analysed were body mass, body mass index, waist circumference, abdominal fat thickness, forced vital capacity (FVC), forced expiratory volume (FEV1) and vital capacity (VC). The Mann-Whitney U-test was used to measure the differences between the group of exercisers and the group of non-exercisers after the second measurement. The level of statistical significance was set at $p<0.05$.

Results

Demographic characteristics of the respondents

The sample on which the study was conducted is homogeneous in terms of age, gender and number of respondents in both the experimental group (N=25) and the control group (N=25). 19 (76%) women and 6 (24%) men were randomly selected in both groups. Significantly more women participated in the study ($p<0.001$). Median age and interquartile range was 52 (49-59) for ES and 52 (48-61) for the control group. ES had an age range of 23-64 years and KS of 26-64 years.

The demographic characteristics of the respondents can be found in Table 1.

The Wilcoxon test confirmed that the subjects had a statistically significant lower body mass ($p<0.001$), a lower body mass index ($p<0.001$), a lower waist circumference ($p<0.001$) and a lower abdominal fat thickness ($p<0.001$) at the second measurement. (Table 1).

Table 1. Descriptive data for the analysed parameters of the anthropological measurements

Variables	Measurements	Median	IQR	Min-max	Wilcoxon test p
Body mass	1.	103	92-114	69-157	<0.001
	2.	97	88-105	66-144	
Body mass index	1.	35.18	33-41	28-64	<0.001
	2.	34.16	31-39	27-56	
Waist circumference	1.	117	110-124	92-145	<0.001
	2.	114	105-120	88-140	
Abdominal fat thickness	1.	13	11-16	8-23	<0.001
	2.	12	10-15	6-20	

Legend: IQR= interquartile range; min-max= minimum and maximum result;

In the second measurement, the Wilcoxon test confirmed that the subjects achieved statistically significantly higher values for all measured parameters than in the first measurement: forced vital capacity ($p<0.001$), forced expiratory volume in the first second ($p<0.001$) and vital capacity ($p<0.001$) (Table 2).

Table 2. Descriptive data for the lung function parameters tested

Variables	Measurements	Median	IQR	Min-max	Wilcoxon test p
FVC	1.	3.11	2.77-3.52	2.25-5.20	<0.001
	2.	3.25	2.87-3.59	2.25-5.47	
FEV1	1.	2.66	2.33-3.04	1.86-4.2	<0.001
	2.	2.70	2.77-3.52	2.25-5.2	
VC	1.	2.76	2.55-3.03	2.34-4.23	<0.001
	2.	2.80	2.58-3.07	2.35-4.27	

Legend: FVC- forced vital capacity; FEV1- forced expiratory volume in the first second; VC- vital capacity; IQR= interquartile range; min-max= minimum and maximum result;

Functional outcomes

As differences were found between the first and second measurements for all parameters, only the parameters determined in the second measurement for the group of test subjects who exercised (experimental group) and for the group of test subjects who did not exercise (control group) were analysed further. The differences were calculated using the Mann-Whitney U test.

Tables 3 and 4 show the medians and interquartile ranges of the parameters of the subjects who were divided into two test groups – subjects who exercised (1) and subjects who did not exercise (2). The parameters for body mass, body mass in-

Table 3. Medians and interquartile ranges for the parameters of the anthropological measurements between the two test groups

Variables	Exercise	Measurements	Median	IQR	p
Body mass	1.	1.	101	92-108	< 0.001
		2.	95	88-103	
	2.	1.	106	87-110	< 0.001
		2.	100	87-110	
	p*	0.244			
Body mass index	1.	1.	35	33-39	< 0.001
		2.	33	31-35	
	2.	1.	38	33-41	< 0.001
		2.	37	31-40	
	p*	0.154			
Waist circumference	1.	1.	118	107-123	< 0.001
		2.	100	102-118	
	2.	1.	117	111-124	< 0.001
		2.	115	108-120	
	p*	0.382			
Abdominal fat thickness	1.	1.	13	11-15	< 0.001
		2.	12	10-14	
	2.	1.	13	11-16	< 0.001
		2.	12	10-15	
	p*	0.435			

Legend: Exercise– 1 = group that trained, 2 = group that did not train; measurement – 1. first measurement, 2. second measurement; IQR = interquartile range; P*significance determined by the Mann-Whitney test for the second measurement between the groups of exercisers (1) and non-exercisers (2);

Table 4. Medians and interquartile ranges for lung function parameters between the two test groups

Variables	Exercise	Measurements	Median	IKR	p
FVC	1.	1.	3.11	2.82-3.63	< 0.001
		2.	3.25	2.99-3.65	
	2.	1.	3.13	2.64-3.54	< 0.001
		2.	3.25	2.81-3.62	
	p*	0.741			
FEV1	1.	1.	2.66	2.37-3.13	< 0.001
		2.	2.69	2.4-3.16	
	2.	1.	2.71	2.29-3.05	0.009
		2.	2.76	2.33-3.12	
	p*	0.676			
VC	1.	1.	2.72	2.55-3.35	< 0.001
		2.	2.77	2.58-3.38	
	2.	1.	2.78	2.51-3.01	< 0.001
		2.	2.85	2.56-3.03	
	p*	0.892			

Legend: Exercise – 1 = group that exercised, 2 = group that did not exercise; measurement – 1. first measurement, 2. second measurement; IQR = interquartile range; P*significance determined by the Mann-Whitney test for the second measurement between the groups of exercisers (1) and non-exercisers (2);

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dex, waist circumference, abdominal fat thickness, forced vital capacity (FVC), forced expiratory volume (FEV1) and vital capacity (VC) are shown. The differences between the groups were calculated using Friedman's ANOVA.

Discussion

The research results showed that there were no differences in functional recovery of lung function and anthropological characteristics between the group that exercised and the group that did not exercise in any of the variables tested. Examining Table 3 and the descriptive statistics between groups, most variables show better outcomes in the exercising group compared to the non-exercising group. However, the additional effect of physical activity may be difficult to detect statistically, likely due to the calorie-restrictive diet to which both groups were subjected.

The proportion of women in the research was significantly higher than that of men. A meta-analysis by Mabira et al. on the influence of age, gender and BMI on the effect of fast walking in obese people also shows a higher representation of women compared to men. The above data supports the hypothesis that women are more prone to developing obesity, but at the same time are more willing to accept the consequences. They are more willing to adopt lifestyle habits that have an impact on improving their condition, which is most likely related to social factors (Mabire, Mani, Liu, Mulligan, & Baxter, 2017).

Chheda et al. investigated the effect of 6 weeks of exercise on FEV1 in obese people and found no statistically significant improvement in the measured parameter. They concluded that regular physical activity can have a positive effect on improving lung function, but that other lifestyle habits of the subjects, such as diet and environmental factors, should also be taken into account (Chheda & Manwadkar, 2021).

Sa-nguanmoo et al. investigated the influence of physical activity on lung function and respiratory muscle strength in obese young adults. They were categorised into groups according to the metabolic equivalent of physical activity. They concluded that higher FEV1 and MIP (maximum inspiratory pressure) measured in physically active young adults indicate that regular physical activity positively affects lung function and inspiratory muscle strength in overweight individuals (Sa-nguanmoo, Chuatrakoon, Pratanaphon, Thanagosai, & Sriarpon, 2023).

Chlif et al. also investigated the effect of aerobic exercise training on ventilatory efficiency and respiratory drive in obese individuals. The subjects exercised five times a week for eight weeks. The results showed that there was no significant difference in the predictive values of predicted FEV and FVC1 before and after the study (Chlif, Chaouachi, & Ahmaidi, 2017).

Numerous studies highlight various factors influencing the functional improvement of lung function in overweight patients. The statistically significant improvement in the measured parameters relates not only to physical activity, but also to other aspects of obesity, such as BMI and the extent of central obesity. In their study, Svartengren et al (2020) used data from the Swedish EpiHealth cohort study, which was conducted with the primary aim of investigating how interactions between lifestyle factors and genotypes contribute to the development of certain disorders in humans. They found that increased waist circumference was associated with lower FEV1 independently of BMI, and similar results were found for FVC. They found that only subjects with a high level of physical activity had an improvement in FVC values; FEV1 and VC (C.-K. Lin & Lin, 2012).

The relative improvement in respiratory parameters was also confirmed in the study by Silva-Rais et al., which looked at the effect of physical activity in combination with resistance training and aerobic exercise on improving lung function and mechanics in overweight or obese women. After a 12-week physical activity programme, they concluded that combined training had a beneficial effect on reducing visceral adipose tissue and improving functional capacity in middle-aged women who had increased body mass or obesity. It was also found that people with overweight and 1st degree obesity have an increased amount of visceral fat, which negatively affects the mechanics of the lungs by damaging the airways, resistance and elasticity of the tissue (Silva-Reis et al., 2022).

The influence of intensity and duration of physical activity on the reduction of adipose tissue was analysed by a group of Canadian experts (Cowan et al). The subjects were divided into groups that exercised at different intensities, determined by the percentage of maximum oxygen uptake, and there was a control group of non-exercisers. The loss in the amount of subcutaneous abdominal fat thickness was not statistically different between the groups of exercisers, but a statistically significant difference was confirmed between the group of non-exercisers and exercisers. In addition, body weight and waist circumference decreased in all groups that exercised compared to the non-exercising group. The study confirmed a significant reduction in total and abdominal fat thickness and concluded that exercise is a good strategy for reducing obesity when done appropriately (Cowan et al., 2018).

Performing aerobic training to test respiratory function in obese men emphasises the positive result of the study by İşleyen and Dağlıoğlu (İŞleyen & Dağlioğlu, 2020). They concluded that after performing an aerobic training programme 3 times a week at 70% of maximal oxygen uptake, there was an improvement in respiratory parameters, namely VC, FVC and FEV1 (İŞleyen & Dağlioğlu, 2020). A very similar study was conducted to determine the effect of selected aerobic exercises on lung function in obese adolescents. A statistically significant difference was found for VC, FVC and FEV1 between the experimental groups that performed aerobic physical activity and the control group that did not exercise (Irandoust, 2015).

Scientists from California investigated the effects of aerobic exercise and an anti-atherosclerotic diet on the amount of visceral adipose tissue and subcutaneous abdominal adipose. They concluded that there was no statistically significant difference between the results of subjects who performed aerobic physical activity and followed an anti-atherosclerotic diet and subjects who followed a diet alone, i.e. the control group who neither exercised nor followed a diet (J.-H. Lin, Liang, Fang, & Teng, 2021). As both groups followed a calorie-restrictive diet, the diet itself could have significantly influenced the results and partly masked the effects of physical activity. Caloric restriction mobilises body fat, reducing both visceral and subcutaneous fat depots, which decreases skinfold thickness and body mass index regardless of physical activity level. Fat reduction in the abdominal and thoracic regions lowers the mechanical load on the lungs and diaphragm, potentially improving pulmonary function (FEV_1, FVC) and ventilatory parameters. The combination of diet and exercise may have reduced differences between groups, as the diet alone already induced metabolic and biological changes affecting the respiratory system and body composition.

Kordi et al. (2015) investigated the effect of abdominal muscle strengthening exercises on abdominal fat tissue in obese women. After a 12-week intervention with abdominal muscle strengthening exercises and a diet programme compared to a diet-only programme, no significant differences were found in measurements of subcutaneous adipose tissue thickness, waist circumference, hip circumference and BMI, although all participants lost body weight (Kordi, Dehghani, Noormohammadpour, Rostami, & Mansournia, 2015).

Limitations of the study

This study has several methodological and statistical limitations that should be considered when interpreting the results. The wide age range (from 23 to 64 years) may have influenced outcomes due to age-related differences in physiological responses to exercise. In addition, the inability to precisely monitor exercise intensity limits interpretation of the dose–response relationship between physical activity and the observed changes. Moreover, information on whether participants in the control group engaged in independent physical activity outside the programme was not collected, which could have influenced the results. From a statistical perspective, interaction effects between group and time were not assessed, preventing definitive conclusions regarding differential changes in outcomes between exercisers and non-exercisers over the study period.

Conclusion

There was no confirmed difference between subjects who exercised in an organised manner and those who did not, but a statistically significant difference was found between the first and second measurement in all subjects. The results obtained suggest that the application of a restrictive diet has a positive effect on the improvement of anthropometric characteristics and lung function parameters in overweight or obese subjects.

Despite the lack of significant differences between the exercise and non-exercise groups in this study, existing research demonstrates that weight loss contributes to functional recovery. Therefore, it remains essential to include regular physical activity as a primary method for restoring the functions of various organ systems in individuals with obesity and for reducing numerous associated risk factors.

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Conflict of Interest

The authors declare that there is no conflict of interest.

Disclosure statement

The authors declare that there is no conflict of interest with any financial organization in relation to the research problem discussed in the manuscript.

Ethical Approval Information

Measurements were taken according to the ethical standards of the Declaration of Helsinki.

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