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Effects of Diaphragmatic Mobilization Techniques on Respiratory Functions, Respiratory Muscle Strength and Resting Metabolic Rate in Obese Individuals

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Abstract

With increasing life expectancy and increasing population, obesity-related diseases getting more common becomes an inevitable issue. Effects of diaphragmatic mobilization methods applied to obese individuals to relief respiratory problems are unknown. It was aimed to investigate the effects of mobilization techniques on respiratory functions, respiratory muscle strenght and resting metabolic rate in obese individuals. Individuals between the ages of 18-65 whose BMI values 30 kg/m^2 and above were included. The sociodemographic information was recorded, and randomly divided into diaphragmatic mobilization (n = 20) and control group (n = 20). Diaphragmatic mobilization techniques (diaphragm translation technique, diaphragm stretching technique, diaphragm eight technique) were applied for 15-20 min, 2 sessions per week, for 4 weeks. Respiratory functions of individuals were evaluated with spirometric measurements, respiratory muscle strength with respiratory muscle force measuring device, resting metabolism rate with indirect calorimeter device, dyspnea with Modified Medical Research Dyspnea Scale. Within-group differences analyze showed improvement in SFT; PEF, all of the respiratory muscle strength and resting metabolic rate measurement parameters in diaphragmatic mobilization group ($p<0.05$) whereas in control group there was no improvement ($p>0.05$). When the differences between the parameters were examined, significant differences were found in favor of the diaphragmatic mobilization group in $FEF_{\%25-75}$, MVV and respiratory muscle strength measurements ($p<0.05$). As a result, it is thought that diaphragmatic mobilization techniques are a safe and feasible approach in obese individuals and these effects should be examined in more disease and different disease groups in future studies.

Keywords

Obesity, Diaphragm, Mobilization, Respiratory functions, Metabolic rate

Introduction

Obesity is an increasingly prevalent health problem worldwide, primarily in developed countries. Obesity is in second place after smoking among the preventable causes of death [1]. Obesity is defined as an increment in the amount of lipids in the body composition in such a way that negatively affects human health. The reasons for the increase of obesity are factors such as consuming high-calorie foods, low physical activity and increasing use of transportation means [2]. Obesity is a chronic disease characterized by storing excessive fat in the body, causing an increase in morbidity and mortality due to its negative effects on endocrine,

cardiovascular, respiratory, gastrointestinal, genitourinary and musculoskeletal system [2].

The National Institutes of Health and WHO classify overweight as having a body mass index (BMI) between 25.0 and 29.9 kg/m^2, and obesity as having a BMI greater than 30 kg/m^2 [3]. Obesity has complications such as cardiovascular diseases, diabetes and causes a decrease in life expectancy [4]. Recent studies show that the abdominal obesity increased at a higher rate than general obesity [5]. The global obesity epidemic seems to be one of the reasons that make health worse in the world [6].

When the influences on obesity are examined, it is also stated that obesity may be related with decreases in respiratory functions [7]. The mechanical properties of the lungs and chest wall are altered significantly in obesity, related with the fat deposits in the mediastinum and the abdominal aera. The decline in respiratory compliance also exchange the breathing pattern. Air typically flows into the lungs along the negative pressure gradient within the pleural space. In obesity, intra-abdominal and pleural pressures are high due to the accumulation of fat in the thoracic and abdominal cavities. This limits the downward movement of the diaphragm and the outward movement of the chest wall. This alters results in a reduction in expiratory reserve volume (ERV) and functional residual capacity (FRC) [8, 9]. Excess fat tissue in the abdomen puts pressure on the chest area, this pressure prevents the expansion of the rib cage during breathing and reduces the movement of the chest wall [9]. Obesity especially increases the incidence of chronic respiratory problems [10]. Both lungs and chest wall should be able to expand with little effort for proper and adequate breathing to occur. If this cannot be actualized by the lung or chest wall is blocked for any reason, insufficient ventilation or excessive fatigue of the respiratory muscles occurs. In cases such as obesity, there is a restrictive condition in the chest wall [8].

In recent years, manual therapy methods are one of the methods used in respiratory problems [11]. Thoracic manual treatment approaches are includes stretching the respiratory muscles, soft tissue massage and relaxation of the muscles [12]. The purpose of these techniques is to improve the function and circulation of the lungs by increasing the mobility of the rib cage and spine and also increase the mobility of the thoracic structures involved in respiratory mechanics [13,14]. The Manual Diaphragm Release Technique is an intervention intended to directly stretch the diaphragmatic muscle fibres. Manual treatment approaches applied to the thorax can be used as treatment in respiratory disorders [15].

Diaphragmatic muscle dysfunctions cause disruptions in respiratory patterns and disturb physiological balance between body systems [16,17]. The physiological changes of the diaphragm muscle and mobility have been investigated in chronic lung diseases [18]. However, to our literature review there are only a few studies on diaphragm mobilization [12, 19, 20]. Although the effects of manual techniques, especially diaphragm techniques, have been studied in a limited number of studies in obstructive pulmonary diseases, according to our literature review, the effects of these techniques have not been investigated in restrictive lung diseases and obesity.

Aim of the study was to examine the effects of diaphragmatic mobilization techniques on respiratory functions, respiratory muscle strength and resting metabolic rate in obese individuals.

Materials and Methods

This randomized controlled study was carried out by random method to examine the effects of diaphragmatic mobilization techniques on the respiratory functions, respiratory muscle strength and resting metabolic rate of obese individuals. The study carried out between January 2020 and March 2020.

Obese individuals between the ages of 18-65 with BMI values of 30 kg/m^2 or over and meeting the inclusion criteria are included in the study. Individuals who have undergone any surgical operation in the last 6 months, being pregnancy, and that have physical, cognitive, cardiac or neurological diseases that may interfere with our evaluation and practices were not included in the study. Verbal and written information was given to the individuals included in the study before the evaluations and informed consent was obtained.

Individuals were randomly divided into two groups as diaphragmatic mobilization and control groups. Diaphragmatic mobilization techniques were applied to obese individuals in the first group by a trained physiotherapist for a total of 4 weeks, 2 times a week, on average 15-20 minutes. Obese individuals in the control group were evaluated before and after the 4 weeks of study and no application was made. Randomization of the groups was determined using the computer numbering system.

This study was approved by Baskent University Medical and Health Sciences Research Board and Ethics Committee (Project no:KA19/393) and supported by Baskent University Research Fund.

Sociodemographic characteristics, age, height, body weight and BMI values of the individuals were recorded. The pulmonary functions of the individuals were evaluated in the sitting position using the spirometer device (COSMED, Micro Quark Spirometer, Rome, Italy) according to the ATS/ERS criteria [21, 22]. Forced vital capacity (FVC), first-second forced expiratory volume (FEV_1), FEV_1/FVC, peak expiratory rate (PEF), 25-75% of forced expiratory flow rate (FEF) (25-75%) and maximum voluntary ventilation (MVV) values were recorded along with expected values and percentages by age, height, body weight and gender.

Respiratory muscle strength measurement device (PowerBreathe, K5, HaB International Ltd, UK) was used for respiratory muscle strength measurement. During the measurement the participant is supported in a chair without back or handles, shoulders placed in a loose sitting position and the nose closed with a nose clip, the patient was asked to take a deep breath with a device placed within his/her mouth and the resulting S_{index} (Inspiratory muscle strength), peak flow (F) and volume (V) parameters were recorded. The evaluation was repeated 3 times; the highest value was recorded [23].

Resting oxygen consumption and energy consumption were measured with an indirect calorimeter device (COSMED, Fitmate Pro, Rome, Italy). According to the measurement criteria. The person to be measured was asked to come to the measurement with a 10-hour fast. Before the measurement, individuals were allowed to sit with their backs supported for 10 minutes in order to ensure respiratory control. The measurement was carried out in sitting position with the help of a mask attached to the mouth and nose area by measuring respiratory gas. During the measurement, individuals were asked to breathe normally and not to speak. The measurement continued for 15 minutes. At the end of the test, the resting oxygen consumption value (VO_2) (ml/min), mean ventilation (VE) (L/min) and resting metabolic rate (Kcal/h) values were recorded [24]

Modified Medical Research Dyspnea Scale (MMRDS) was used to determine the breathlessness levels of individuals [25].

Diaphragmatic manual mobilization techniques

Manual mobilization techniques specific to the diaphragm applied an average of 15-20 minutes, 2 times a week, 4 weeks. Four different manual mobilization techniques that we determined specifically for obese individuals were applied as described below (Figure 1).

Diaphragm translation technique

In this application, the individual lies in a supine position with a relaxing outfit, arms near the trunk, feet straight and placed in a loose position. The physiotherapist is standing on the edge of the bed with his face facing the patient. The physiotherapist grasps both hands gently to the lower rib. First, he applies a push from the outside with his right hand, then he applies a push with his left hand. This process continues for one minute. During the application, the patient is asked to breathe normally [26, 27].

Diaphragm stretching technique with deep breathing

In this application, the individual is positioned on the bed with the back of the arms loose and next to the trunk, with the feet extended loosely next to each other. The physiotherapist stands at the patient's shoulder and on the edge of the bed, grasping both hands under the patient's lower rib. The physiotherapist wants the patient to take a deep breath. When the patient breathes, he moves with ribs, and when he exhales, he prevents the movement of ribs. It completes this mobilization with three deep breaths [26, 27].

Diaphragm stretching technique with normal breathing

In this technique, the individual is sitting at the edge of the bed, the physiotherapist stands behind the patient and extends his/her arms from the back of the patient, placing the inner part of his/her hands in the lower ribs of the patient .The physiotherapist asks the patient to breathe normally, at this moment, she/he directs her hands with ribs in the direction that the ribs open, and prevents the movement of the ribs while the patient exhales. This mobilization application continues for 2-4 minutes (27, 28).

Diaphragm eight technique

In this technique, the individual lies on his back, the physiotherapist is facing the patient's face and stands on the edge of the bed. The physiotherapist grasps the lower ribs of the patient with both hands and mobilizes the lower ribs with his left hand upwards and towards the midline of the body, then



Diaphragm Translation Technique





Diaphragm Stretching Technique (deep breathing)



Diaphragm Stretching Technique (normal breathing)



Diaphragm Eight Technique

Figure 1: Diaphragmatic manual mobilization techniques.

mobilizes the lower ribs of the patient with his right hand upwards and towards the midline of the body. This mobilization continues rhythmically for 2-4 minutes. During this application, the patient is asked to breathe normally [26, 27].

Statistical analysis

The data obtained from the participants were analyzed using the statistics program (SPSS) version 21.0 prepared for the social sciences (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp). The data are presented in the tables and graphs using percentages and mean as the central distribution criterion and standard deviation as the spread criterion. Confidence interval was accepted as 95%. The homogeneity of the groups in terms of descriptive statistics was analyzed with the Shapiro Wilk Test. In order to analyze the differences between groups, non-parametric Mann Whitney U test or in cases where continuous variables can fulfill the parametric test assumptions, independent two groups comparison Independent Two groups 't' Test (Students' t test) were applied. In order to analyze the differences between dependent groups Wilcoxon or Paired T Test was applied. According to the power analysis results, the sample number was calculated as 16 for each group for 85% power and 95% reliability.

Results

Including 20 individuals in the diaphragmatic mobilization group and 20 individuals in the control group were examined. At the end of the study 3 participants in the diaphragmatic mobilization group and 3 participants in the control group could not complete the study due to the Covid-19 pandemic process and 17 people in the education group and 17 people in the control group completed the study. No adverse events were encountered during the study. There was no significant difference in all parameters in the groups included in the study (p>0.05) (Table 1). Descriptive characteristics of the participants are shown in table 2.

When the intra-group differences of the pulmonary function test parameters were analyzed, the PEF (p = 0.011) parameter significant different in the diaphragmatic mobilization group (p>0.05). In the control group, only the MVV (p=0.028) parameter significantly increased and other parameters were not significantly different (p>0.05) (Table 3).

When the within-group differences of the respiratory muscle strength measurement parameters were analyzed all parameters in diaphragmatic mobilization group significantly increased (p<0.05) and all parameters in control group significantly decreased (p <0.05), (Table 3).

Considering the differences in basal metabolic rate before and after the treatment, there was a significant difference in all parameters in the diaphragmatic mobilization group (p<0.05), but no statistically significant difference was found in the control group (p>0.05), (Table 3).

The differences in Medical Research Dyspnea Scale before and after treatment, there was no statistically significant difference in both groups (p> 0.05), (Table 3).

When the differences between the all measurement parameters were examined, significant differences were found in favor of the diaphragmatic mobilization group in FEF %25-75 (L) p=0.016, MVV (L) (p=0.005), MVV (%) (p = 0.010), MIP (cmH_2O) (p=0.005), Peak Inspiratory Flow (L/sn) (p = 0.019) and Volume (L) (p = 0.003) values (Table 3).

Discussion

As a result of our study, significant improvements in respiratory functions, respiratory muscle strength and resting metabolic rate were obtained with diaphragmatic mobilization in obese individuals.

Studies in previous years show that manual therapy has the potential to affect and alter respiratory mechanics in some chronic lung diseases, such as chronic asthma and COPD, and this includes the elasticity of the chest wall and thoracic movement. It is stated that this may indirectly give rise to an enhancement in exercise capacity and lung function [28, 29]. Pathological conditions affecting the respiratory system disturb the structure of the diaphragm muscle mechanically, decreasing the length of the diaphragm in the working direction, decreasing its function by changing the mechanical connection between the diaphragm parts, becoming a disadvantage. This reduces the effect of raising and enlarging the lower rib cage, as it will reduce the movement of the diaphragm, and improves respiratory work and reduces functional capacity [30].

Table 1: Sociodemographic characteristics of the participants.

	Diaphragmatic Mobilization Group (n=20) X ± SD	Control Group (n=20) X ± SD	Total X ± SD	p
Age (years)	37,00 ± 9,02	39,22 ± 11,89	38,11 ± 10,46	0,667
Length (cm)	169,44 ± 8,33	168,05 ± 8,29	168,75 ± 8,22	0,500
Body weight (kg)	89,72 ± 10,40	89,16 ± 9,84	89,44 ± 9,98	0,333
BMI (kg/m^2)	31,16 ± 1,56	31,60 ± 2,32	31,38 ± 1,96	0,500

Table 2: Descriptive characteristics of the participants.

n (%)		Diaphragmatic Mobilization Group (n = 20)	Control Group (n = 20)	Total
Gender	Female	6 (%30)	9 (%45)	15 (%37,5)
	Male	14 (%70)	11 (%55)	25 (%62,5)
Education Status	Primary school	0	1 (%5)	1 (%2,5)
	Middle School	1 (%5)	3 (%15)	4 (%10)
	High school	8 (%40)	9 (%45)	17 (%42,5)
	University	10 (%50)	7 (%35)	17 (%42,5)
	Doctorate	1 (%5)	0	1 (%2,5)
Smoking Habit	Yes	4 (%20)	6 (%30)	10 (%25)
	No	16 (%80)	14 (%70)	30 (%75)

n = Number, % = Percentage

Table 3: Comparison of all outcome measurements between groups.

	Diaphragmatic Mobilization Group (n = 17)			Control Group (n = 17)		
	X ± SD		p	X ± SD		p
	Before	After		Before	After	
FEV_1 (L)	3,02 ± 0,66	3,15 ± 0,58	0,535	2,86 ± 0,67	2,99 ± 0,70	0,408
FEV_1 (%)	86,22 ± 16,13	90,88 ± 16,72	0,266	78,55 ± 11,01	83,29 ± 13,06	0,393
FVC (L)	4,08 ± 0,78	4,15 ± 0,60	0,287	3,76 ± 0,68	3,98 ± 0,78	0,246
FVC (%)	97,72 ± 12,97	101,82 ± 16,41	0,073	89,44 ± 10,79	92,35 ± 12,52	0,831
FEV_1/FVC	73,24 ± 11,19	76,95 ± 8,49	0,619	72,36 ± 11,48	73,10 ± 10,35	0,586
PEF (L/sn)	4,54 ± 2,10	6,25 ± 2,12	**0,011***	4,45 ± 2,15	4,50 ± 2,15	0,758
FEF %25-75 (L)	2,94 ± 1,03	2,94 ± 1,23£	0,435	2,75 ± 1,06	2,94 ± 1,02	0,255
MVV (L)	72,93 ± 27,34	79,35 ± 18,03£	0,149	74,61 ± 19,47	68,38 ± 16,30	**0,028***
MVV (%)	56,55 ± 15,67	63,94 ± 15,67£	0,170	61,72 ± 14,77	56,76 ± 11,29	0,108
MIP (cmH_2O)	75,16 ± 12,58	83,88 ± 13,56£	**0,001***	83,22 ± 10,14	80,47 ± 9,50	**0,003***
Peak Inspiratory Flow (L/sn)	3,56 ± 1,26	4,67 ± 0,87£	**0,002***	3,63 ± 1,30	3,22 ± 1,24	**0,001***
Volume (L)	2,12 ± 0,48	2,96 ± 0,93£	**0,006***	2,32 ± 0,60	2,01 ± 0,26	**0,004***
Resting VO_2 (ml/min)	230,44 ± 54,71	282,11 ± 57,98	**0,002***	246,44 ± 48,78	235,70 ± 51,96	0,134
Resting VE (L/min)	7,98 ± 2,34	9,49 ± 2,02	**0,015***	7,90 ± 1,89	7,54 ± 1,86	0,097
Resting Metabolic Rate (Kcal/h)	1598,00 ± 378,00	1963,52 ± 405,02	**0,002***	1659,33 ± 336,63	1621,35 ± 366,49	0,093
MMRDS	1,50 ± 0,51	1,47 ± 0,51	0,317	1,55 ± 0,51	1,47 ± 0,51	0,317

X ± SD = Mean ± Standard Deviation, % = Percent, L = Liter, n = Number, ES = Effect Size, FVC = Forced Vital Capacity, FEV_1 = Forced Expiratory Volume in the First Second, FEV_1/FVC = The Ratio of the Forced Expiratory Volume in the First Second to the Forced Vital Capacity, PEF = Peak Expiratory Rate, $FEF_{(\%25\text{-}75)}$ = 25-75% Flow Rate of Forced Expiratory Volume, VC = Vital Capacity, IC = Inspiratory Capacity, MVV = Maximum Voluntary Ventilation, MIP = Maximum Inspiratory Pressure, VO_2= Oxygen consumption, VE=Ventilation, MMRDS = Modified Medical Research Dyspnea Scale, Wilcoxon Test, *p<0,05, Mann-Whitney U Test, £ p <0.05

According to our literature review, there is no study examining the effect of diaphragmatic mobilization techniques on respiratory functions, respiratory muscle strength and resting metabolic rate in obese individuals. In this sense, our study gains importance of being the first study in this group to examine the effects of diaphragmatic mobilization techniques with a control group.

In our study, after the 4-week diaphragmatic mobilization application, it was observed that only significant PEF parameter could be obtained in the respiratory test measurements of obese individuals. In the study of Gonza ´lez-A ´lvarez et al. to investigate the effects of diaphragmatic mobilization techniques on healthy individuals an increase in FEV_1 and FVC parameters in respiratory functions have been reported [31]. Noll et al. reported that a manual treatment session involving the diaphragmatic mobilization technique improves respiratory function by looking at the acute effect of patients with COPD [13]. Abdaleel et al. also found that the diaphragmatic mobilization technique significantly increased FVC, FEV_1 and six minutes walking distance in patients with COPD [32]. Similarly, in a study conducted by Rocha et al, it was stated that diaphragmatic mobility improved inspiratory capacity in patients with clinically stable COPD who did not have an exacerbation history in the last 6 weeks in the study that used the diaphragmatic mobilization technique [20]. Yelvar et al. found that a single manual therapy session with diaphragmatic mobilization improved FEV_1 and vital capacity in severe COPD [33]. In a similar study, Hakala et al. reported that they achieved significant improvements in PEF, spirometry, and lung volumes in their study, where they examined the effects of weight loss on peak flow variability, airway obstruction and lung volumes in obese patients with asthma [34]. When we look at our study and studies on chronic respiratory diseases and healthy people, it can be seen that, especially diaphragmatic mobilization techniques may have the potential to improve respiratory functions. In our study, only a significant improvement in the PEF parameter was obtained and it was found to be moderately effective, especially considering that this parameter is related to respiratory muscle strength, it can be thought that the result obtained is satisfactory. It can also be said that the fact that a significant difference in other parameters could not be obtained may also depend on our case count and application time.

In obesity due to the excessive fatty tissues in the body individuals breathe using the upper chest muscles and generally have a flexion posture, just like chronic obstructive pulmonary diseases. This change causes a raise in auxiliary respiratory muscle activity [35]. Therefore, in obese individuals, respiratory muscle strength is expected to decrease and approaches to improve it need to be examined. In our study, a significant improvement was achieved in the maximum inspiratory pressure and peak inspiratory flow values of obese individuals after diaphragmatic mobilization techniques. It can be thought that manual techniques provide an increase in thoracic mobility and chest wall compliance with relaxation. It is also found that thoracic cage flexibility and muscle relaxation reduced respiratory effort and increased muscle function, and in this way an increase in respiratory muscle strength was achieved. Yelvar et al. examined the acute responses of similar diaphragmatic mobilization techniques to severe COPD patients and found inspiratory muscle strength improvement [33]. Rocha et al, achieved a similar development with our study of inspiratory muscle strength after 2 weeks, 6 sessions and manual diaphragmatic technique applied in their study in COPD [36].

Obesity affects various physiological variables that can cause dyspnea, especially during exercise, in the absence of other health problems [37]. The mechanical properties of the lungs and chest wall vary significantly in obesity, largely due to the mediastinum and fat deposits in the abdominal cavities. These changes reduce the compatibility of the chest wall of the lungs and the entire respiratory system, and possibly contribute to the respiratory symptoms of obesity, such as wheezing, shortness of breath [38, 39]. In a study on healthy obese women, moderate weight loss was reported to significantly improve dyspnea [40]. It was observed that the shortness of breath that was evaluated with MMRDS in obese individuals, where we applied the diaphragmatic mobilization techniques of the studies, did not change significantly after 4 weeks of application. This is since obese individuals who participated in our study had low perception of breathlessness at the beginning and our method of evaluating breathlessness.

Resting metabolic rate is the component of the largest proportion of total daily energy expenditure. However, the etiology of low resting metabolic rate in obesity is still unclear and controversial. It is stated that resting metabolic rate has a strong genetic component and is a predictor of subsequent weight change for a given body composition [41]. In a study, the resting metabolic rate evaluated in obese subjects is 3-5% lower than controls. They concluded that because of an irreversible decrease in metabolic rate, weight loss is possible. They also stated that this decline may also be a normal physiological fact caused by energy restriction and weight loss. In another study, it is stated that any factor that increases the metabolic rate can provide weight control and loss [41]. In our study, we found that there was a significant difference in resting metabolic rate, resting oxygen consumption and ventilation values in obese individuals after diaphragmatic mobilization for 4 weeks. There is no other study evaluating diaphragmatic mobilization practices in this respect and in obese individuals. Although there was no change in the weight of our patients at the end of 4 weeks, the fact that we achieved a change in metabolic rates shows us that these applications can be a supportive approach in weight control in the longer term, as Lopes et al. stated.

Our study has some limitations. First of all, having a placebo application on a control group instead of the control group used in this study without any intervention could have contributed to a clearer interpretation of our results. Another limitation is that due to the COVID-19 pandemic we are in, three individuals who would also increase the strength of the results of this study could not complete it and cannot be taken to the final measurements resulting in the completion of the study as 17 education and 17 control groups.

Our study is the first study to investigate the effects of diaphragmatic mobilization techniques in obese individuals. In addition, another strength of our study, which distinguishes it from other studies, is that the effect of manual mobilization technique applied to the diaphragm, as in many other studies, has been examined for a longer period, beyond the acute and short-term effects.

In our study, the participation rate to mobilization techniques was one hundred percent. All individuals in the application group participated in all sessions fully. All the individuals to whom we applied diaphragmatic mobilization techniques stated that they are very satisfied with the applications and recommend them to those with similar complaints. In addition, no side effects developed in any of our participants.

Conclusion

In conclusion, it is thought that diaphragmatic mobilization techniques are a safe and feasible approach in obese individuals, and these effects should be investigated in further studies with more cases and in different disease groups.

Conflict of Interest

Author declare no conflict of interest

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