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Effect of Inspiratory Muscle Training with the Device on Respiratory Functions

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ORIJINAL ARTICLE

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Abstract

Improvements in lung functions and respiratory muscle strength can provide better physical performance and a healthy life. The functions of the respiratory system depend on the capacity of the inspiratory muscles. Inspiratory muscle training can increase respiratory capacity by strengthening the inspiratory muscles. In the light of this information, researches on the inspiratory muscle training have increased in recently. In this study, it is aimed to examine the chronic effect of 4-week inspiratory muscle training with the device (IMT-D) on respiratory functions. Twenty volunteers between the ages of 20-40 participate in the study IMT-D is applied to the participants every day for 4 weeks, with 40% of the maximal inspiratory pressure (MIP) values and 30 repetitions in the morning and the evening. The respiratory functions of the participants (FVC, FEV1, PEF, FEV1/FVC) is determined by spirometry at the beginning of the study, at the end of the 2nd week and at the end of the 4th week. In repeated measurements, Friedman Test is used to determine the differences between the measurements. As results, it is determined that IMT-D provided statistically significant improvement in all respiratory parameters, it is determined that the highest improvement in all parameters is in the last measurements ($p<0.05$). Since it is determined that IMT-D are an important factor in improving respiratory functions, it can be recommended that people use these exercises to increase their quality of life and to protect/improve their health.

Keywords: Lung capacity, Inspiratory muscle training, Sedentary

Aletli İnspiratuar Kası Egzersizinin Solunum Fonksiyonlarına Etkisi

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Öz

Akciğer fonksiyonlarında ve solunum kas gücündeki iyileşmeler daha iyi fiziksel performans ve sağlıklı bir yaşam sağlayabilmektedir. Solunum sisteminin fonksiyonları solunum kaslarının kapasitesine bağlıdır. Solunum kası egzersizleri solunum kaslarını kuvvetlendirerek solunum kapasitelerini artırabilmektedir. Bu bilgiler ışığında son yıllarda solunum kası egzersizleri ile ilgili araştırmalar çoğalmıştır. Bu düşünceler ile yapılan çalışmada dört haftalık aletli solunum kası egzersizlerinin solunum fonksiyonları üzerine olan kronik etkisinin incelenmesi amaçlanmıştır. Çalışmaya 20-40 yaşları arasında 20 gönüllü katılmıştır. Katılımcılara maksimal inspirasyon basıncı (MIP) değerlerinin % 40'ı ile sabah-akşam 30'ar adet olmak üzere dört hafta sürecince her gün aletli solunum kası egzersizi uygulanmıştır. Katılımcıların solunum fonksiyonları (FVC, FEV1, PEF, FEV1/FVC) çalışmanın başında, 2. hafta sonunda ve 4. hafta sonunda spirometre ile belirlenmiştir. Tekrarlı ölçümlerde, ölçümler arasındaki farkı belirlemede Friedman Testi kullanılmıştır. Aletli solunum kası egzersizlerinin solunum parametrelerinin hepsinde istatiksel olarak anlamlı şekilde gelişim sağladığı belirlenirken, bütün parametrelerde en yüksek gelişimin son ölçümlerde olduğu tespit edilmiştir ($p<0,05$). Aletli solunum kası egzersizlerinin solunum fonksiyonlarını geliştirmede önemli bir etken olduğu belirlenirken, kişilerin yaşam kalitelerini artırmada ve sağlıklarını koruma/geliştirmede bu egzersizleri kullanmaları tavsiye edilebilir.

Anahtar kelimeler: Akciğer kapasitesi, Solunum kası egzersizi, Sedanter

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Introduction

The work capacity and performance in our daily lives are closely related to the efficiency of the respiratory system. The effective and efficient functioning of the respiratory system enables the individual to improve their quality of life and lead a healthier life. In order for the amount of oxygen inhaled in daily life to be more efficient, the muscles that help to breathe must be strong and work properly. Increasing the muscle strength of breathing helps to improve the relationship between muscle structure and relaxation of these muscles and to increase the amount of oxygen inhaled (Santos et al., 2012). The diaphragm is the most important muscle affecting respiratory functions among the respiratory system muscles (Hodges et al., 2002). While diaphragm contraction provides approximately 50% of the respiratory volume change during rest, accessory respiratory muscles perform the rest of the work (Sheel, 2002). In diaphragmatic breathing, the dominant use of the diaphragm muscle against the accessory muscles reduces the inspiratory load, increases the ventilation rate of the lungs, and therefore improves breathing (Larson et al., 1996).

Inspiratory muscles, which are accepted as skeletal muscles with their morphological and functional characteristics, respond to training like locomotor muscles when an appropriate training load is applied (Kraemer et al., 2002). It is thought that inspiratory muscle training performed on the diaphragm will contribute to the improvement of movement control in daily activities and are also very effective for strengthening the inspiratory muscles (Enright et al., 2006). The basis of inspiratory muscle training is to reduce shortness of breath, increase inspiratory muscle function and tolerance to exercise (Culver et al., 2017). Inspiratory muscle training is a form of training that is performed using a resistive breathing apparatus and creates a resistance for the muscles involved in the inspiratory processes (Silva et al., 2013). After proper training, respiratory muscles show hypertrophy (Egan and Zierath, 2013). While inspiratory muscle training is often used to treat people with asthma, chronic obstructive pulmonary disease, and airflow limitation (Geddes et al., 2008), recently, sports scientists have been examining this training to identify acute or chronic changes that occur (Bağıran et al., 2019; Yılmaz and Özdal, 2019). Lötters et al. (2002) reported that inspiratory muscle training significantly increase respiratory muscle strength and respiratory muscle endurance, reduce the feeling of shortness of breath at rest and during training, and improve functional exercise capacity. Many studies have found that working the inspiratory muscles appears to be an effective ergogenic aid for exercise performance (Illi et al., 2012). There are several exercises to strengthen the inspiratory muscles. These inspiratory muscle training (pursed lip, diaphragm breathing, use of triflo) can be lined as, supporting positions (sitting upright in the bed, bending over the pillows on the table by the bed, leaning on the knee, leaning back, standing arms or leaning the back on a support), and relaxation techniques (Ergün et al., 2019). While the respiratory resistance is adjusted by the person himself in these exercises, the biggest problem is the lack of a constant pressure and the unknown in which pressure range to work. Also, inspiratory muscle training can be performed with the device. IMT-D can be performed against a resistance with special breathing training equipment whose pressure is adjusted. During the training, the person works by resisting a certain resistance with the inspiratory muscles.

In the literature, it is seen that inspiratory muscle training is studied on people which have respiratory problems (Geddes et al., 2008) and on athletes to increase sports performance (Bağıran et al., 2019; Yılmaz and Özdal, 2019). In addition, in some of these studies, inspiratory muscle training, which are done without tools and which workload is not known, were used. The fact that the sample of the study was composed of sedentary healthy individuals and the application of IMT-D to improve respiratory functions constitute the originality of the study. The aim of this study is to examine the chronic effect of 4-week IMT-D on respiratory functions.

Material and Methods

Research group

The sample of the study consisted of 20 sedentary individuals between the ages of 20-40, who don't have any health issues (pulmonary, cardiovascular disfunction) and smoke. Mean age, average height and weight of the participants are 32.45±6.37, 170,90±846 cm and 66.95±13,88 kg, respectively.

Experimental Setup

Pulmonary function tests of the participants are determined by spirometry. Participants performed instrumented respiratory muscle exercises every day of the week during 4 weeks. Basal levels of the pulmonary function test (pre-test) were determined before the study started (at least 5 minutes at rest). Then, after the 14th day mid-test) and 28th day (post-test), pulmonary function tests are repeated to determine the effect of IMT-D. Repeated measurements are made at the same times of the day, in the same laboratory conditions and with the same spirometer, and the measurements are determined according to the pre-test order of the participants. Considering the COVID-19 pandemic conditions, the participants are given a personalized spirometer mouthpiece and a Powerbreathe K5 and a personalized bacterial filter mouthpiece in the determination of MIP at every stage of the measurements, and the participants were taken to the laboratory one by one. Before the measurement of a second participant, 20 minutes waited and the laboratory is ventilated during the process. In addition, during the process, the devices are disinfected and hygiene rules is applied to the participant.

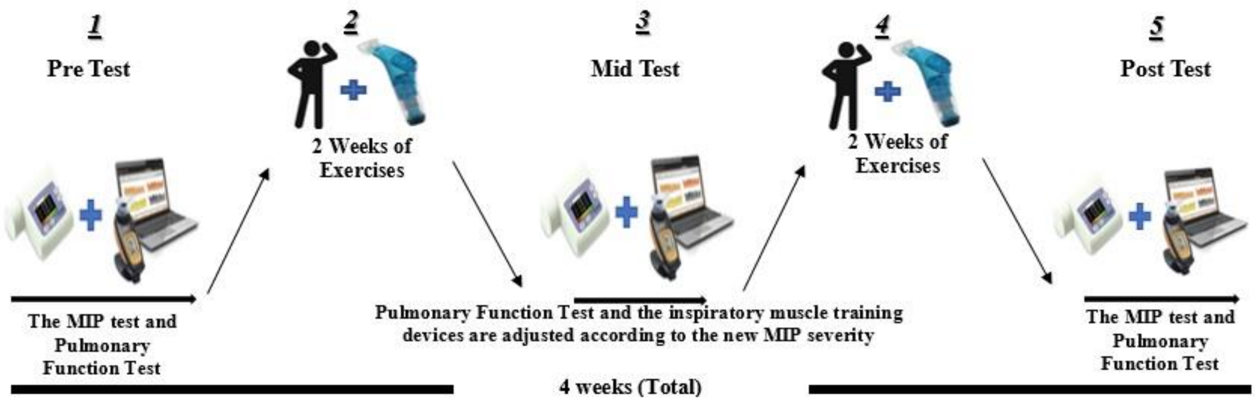

Figure 1. Experimental setup

1: Pre-testing the respiratory function test and MIP measurement of the participants, giving IMT-D to the participants by making personal pressure settings. **2:** Performing 2-weeks of inspiratory muscle training on the inspiratory muscle training set to 40% of the determined MIP. **3:** Repeating the pulmonary function test and MIP measurement, rearranging the pressure settings of the inspiratory muscle training according to the new MIP values. **4:** Performing two weeks of respiratory muscle exercise on the respiratory muscle exerciser set to 40% of the determined MIP. **5:** Post-testing of the participants' pulmonary function test and MIP measurement.

Inspiratory Muscle Training

Proper IMT-D is shown to the participants before the training and necessary information is given about the working principle of the device. Firstly, training applied to the participant by the researcher, and the training is started after the training is performed correctly by the participant. Participants performed inspiratory muscle training using the plus (blue) model of the Powerbreathe inspiratory muscle training with a mechanically adjustable load adjustment range of 23-196 cmH2O (Powerbreathe Plus, UK). Each participant is given a Powerbreathe brand plus (blue) with an intentionally adjusted training load with 40% of the determined MIP. Then, the participants performed the IMT-D with 40% of the MIP, consisting of 30 repetitions in the mornings and the evenings, every day of the week during 4-weeks (30 repetitions in the mornings and in the evening, approximately 8 minutes a day). The inspiratory muscle training loads of the participants is updated again according to the MIP values after the second measurement taken at the end of the 14th day.

Data Collection Tools

Maximum Inspiratory Pressure (MIP) Measurement

Before starting IMT-D, the Powerbreathe K5 device is used to determine the training load (Powerbreathe, Ironman K5, HaB Ltd.,UK). 30 ventilations are performed after entering information (age, kg, height and gender) of the participants to the device. The measurement is taken as two trials and the best value is recorded. After determining the MIP cmH2O, a personalized training load is adjusted for IMT-D with 40% of this pressure.

Pulmonary Function Test

Microlab 3300 brand spirometer device is used to measure the respiratory parameters of the participants. In the study, forced vital capacity (FVC-lt), forced expiratory volume in the first second (FEV1-lt), peak expiratory flow rate (PEF-lt/sec) and FEV1/FVC% measurements are taken from respiratory parameters. Measurements are made with the participants sitting comfortably, by attaching clips to their noses (Marangoz et al., 2016).

Statistical Analysis

The data are analyzed in the SPSS 26 package program. In repeated measurements, Friedman Test, one of the nonparametric tests, is used to determine the difference between measurements. In the study, the level of significance is accepted as $p<0,05$.

Ethics of Research

Ethics committee approval is obtained for the study from Niğde Ömer Halisdemir University Non-Interventional Clinical Research Ethics Committee with the date of 04.11.2021 and the decision number 2021/89. This study is conducted in accordance with the Principles of the Declaration of Helsinki.

Results

Table 1

Means of Descriptive Quartiles of Repeated Measurements and Comparison of the Difference Between them

Variables (n=20)	Measurements	x±sd	Median (% 25-75)	X^2	p	Repetitive Variables	p
MIP (cmH_2O)	Pre-Test	73,28±26,14	63,07 (55,15-85,65)	38,100	,000***	Pre-Test - Mid-Test	,001**
	Mid-Test	88,30±26,66	81,35 (65,94-108,68)			Pre-Test - Post-Test	,000***
	Post-Test	107,21±35,51	104,03 (81,61-119,78)			Mid-Test - Post-Test	,004**
FVC (lt)	Pre-Test	5,04±0,53	5,02 (4,57-5,34)	29,200	,000***	Pre-Test - Mid-Test	,002**
	Mid-Test	5,33±0,48	5,40 (5,04-5,62)			Pre-Test - Post-Test	,000***
	Post-Test	6,61±1,76	5,98 (5,69-7,31)			Mid-Test - Post-Test	,027*
FEV1 (lt)	Pre-Test	4,62±,69	4,81 (4,25-5,01)	30,700	,000***	Pre-Test - Mid-Test	,003**
	Mid-Test	5,09±,54	5,02 (4,88-5,45)			Pre-Test - Post-Test	,000***
	Post-Test	6,24±1,57	5,88 (5,29-6,77)			Mid-Test - Post-Test	,011*
PEF (lt/sn)	Pre-Test	7,93±1,56	7,52 (6,54-9,38)	39,519	,000***	Pre-Test - Mid-Test	,001**
	Mid-Test	8,31±1,46	7,80 (7,02-9,69)			Pre-Test - Post-Test	,000***
	Post-Test	9,31±1,89	9,16 (7,54-11,12)			Mid-Test - Post-Test	,003**
FEV1/FVC %	Pre-Test	85,81±2,87	86,25 (84,15-88,03)	40,000	,000***	Pre-Test - Mid-Test	,002**
	Mid-Test	88,17±2,19	88,30 (87,01-89,95)			Pre-Test - Post-Test	,000***
	Post-Test	89,93±2,30	90,30 (88,43-91,30)			Mid-Test - Post-Test	,002**

*p<0,05 **p<0,01 ***p<0,001

MIP= maximum inspiratory pressure FVC= forced vital capacity FEV1= forced expiratory volume PEF= peak expiratory flow

When the table is examined, a statistically significant difference was found between the pre-test, the mid-test and the post-test. Moreover, in MIP, FVC, FEV1, PEF, FEV1/FVC% values there are differences in favor of the mid-test and post-test against pre-test (p<0.05). Also, a statistically significant difference was found in favor of the post-test when compared with mid-test (p<0,05).

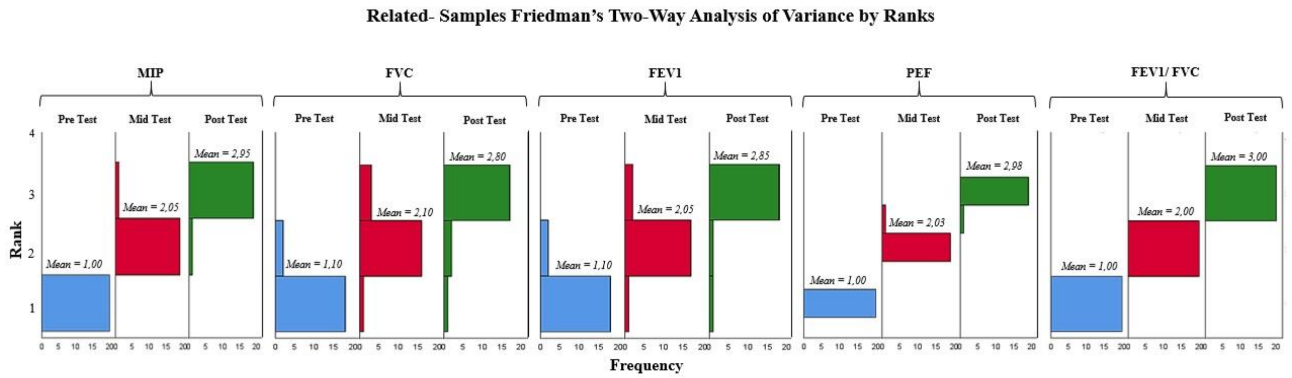

Figure 2. Comparison of respiratory functions and MIP values between measurements

Discussion

Oxygen plays a critical role in energy metabolism in skeletal muscle (McCully and Hamaoka, 2000). With the increased metabolic rate with exercise, an increase in respiratory volume occurs to obtain the oxygen needed. As with physical exercises, inspiratory muscles can be strengthened with inspiratory muscle training and the increase in the current respiratory volume can be made permanent

(Bağıran et al., 2019; Yılmaz and Özdal, 2019). The reason for the increase in respiratory muscle strength with inspiratory muscle training is related to the resistance applied in the training and the structure of the skeletal muscle. Increased respiratory demands during the physical exercise cause an increase in the mechanical power developed by the body in the inspiratory muscles as a result of neural stimuli (Butler et al., 2014). Therefore, the development of new respiratory mechanism-specific training methods for performance can improve neuromuscular responses and respiratory capacity, potentially increasing overall exercise tolerance. Inspiratory muscle training, which is one of these training methods, is an training method that applies additional load to the diaphragm and auxiliary inspiratory muscles in order to increase respiratory power and endurance (Archiza et al., 2018; Guy et al., 2014). Studies in this area report inspiratory muscle training as a useful method to reduce perceptions of both respiratory and peripheral effort (Archiza et al., 2018; Guy et al., 2014). Inspiratory muscle training improves neuromuscular performance and leads to greater improvements in exercise capacity (Archiza et al., 2018; Guy et al., 2014). Moreover, some studies on inspiratory muscle training have indicated that there is more improvement in individuals who are sedentary and participate in sports for longer periods of time (Illi et al., 2012). When the earlier studies are examined, it is clear to see that these studies are supporting the results of our study. A statistically significant difference was found between the pre-test, the mid-test and the post-test. Moreover, in MIP, FVC, FEV1, PEF, FEV1/FVC% values there are differences in favor of the mid-test and post-test against pre-test ($p<0.05$). Also, a statistically significant difference was found in favor of the post-test when compared with mid-test ($p<0,05$).

When the other studies related with inspiratory muscle training was examined, there are limited number of studies on the chronic effect of inspiratory muscle training on respiratory functions in sedentary individuals (Geddes et al., 2008; Öztütüncü and Özdal, 2019). Current studies in the literature are mostly aimed at increasing the performance of athletes and rehabilitation in patients with respiratory problems. For this reason, conducting our study in healthy sedentary individuals will be reflected as an original value in the relevant literature, while limiting the discussion section. In this section, similar studies on sedentary people in the literature are given. Geddes et al. (2008) examined the effects of inspiratory muscle training in sedentary individuals with chronic obstructive pulmonary disease, showed that inspiratory muscle training significantly improved respiratory muscle strength, endurance, exercise capacity, and quality of life. In a different study, the chronic effect of inspiratory muscle training in healthy sedentary male individuals was investigated. In the study inspiratory muscle training was applied to the participants at 40% of the MIP for 4-weeks. According to the results of the study, there was no increase in respiratory muscle strength in the control group participants who did not do any training, while the increase in MIP and MEP values in the group that did inspiratory muscle training was accepted as the most important indicator of respiratory muscle strength increase in healthy sedentary male (Öztütüncü and Özdal, 2019). In another study on sedentary individuals, Bostancı et al. (2019) examined the effects of inspiratory muscle training on respiratory function and respiratory muscle strength in both smokers and non-smokers. Significant increases in respiratory muscle strength and respiratory function were noted after a 4-week exercise period. Significant changes were found in favor of smokers in expiratory muscle strength, slow vital capacity, and forced pulmonary measurements among the participant groups. These results indicate greater improvement in smokers after inspiratory muscle training. This difference between smokers and non-smokers is potentially explained by the greater effect of res inspiratory muscle training on the lung microbiome of smokers, resulting in greater reversal of adverse effects. The basis of inspiratory muscle training is based on increasing respiratory muscle function, reducing shortness of breath and increasing tolerance to exercise (Culver et al., 2017). Inspiratory muscle training increases respiratory muscle strength, resulting in an increase in lung function and volumes after inspiratory muscle training (Lötters et al., 2007).

Although studies with sedentary individuals are limited, there are current studies on athletes. Kilding et al. (2010) stated that inspiratory muscle training applied for 6-weeks had a positive effect on swimming performance of 100 m and 200 m; therefore, inspiratory muscle training could be considered as a valuable ergogenic aid for competitive swimmers. Lomax et al. (2011) examined the effect of inspiratory muscle training for 4-weeks and warming up of the inspiratory muscles before each training on the distance covered on 12 male football players consisting of two groups. According to the results, it was stated that the distance covered in the Yo-Yo test was higher in the group that applied inspiratory muscle training and respiratory muscle warm-up. Bağıran et al. (2019) investigated the effect of inspiratory muscle training applied to swimmers on aerobic power and respiratory parameters. Although there was no significant difference in aerobic power values after 6-weeks of inspiratory muscle training, a positive difference was found in respiratory parameters in favor of the experimental group. In another study in swimmers, it was aimed to determine the combined effects of swimming on inspiratory muscles and respiratory functions. It has been determined that inspiratory muscle training applied in combination with 8-week swimming training have positive chronic effects on respiratory muscle strength and respiratory functions in swimming (Yılmaz and Özdal, 2019). In a study conducted volleyball athletes and sedentary peoples respiratory functions were compared, at the end of the study it was determined that volleyball athletes FEV1, FVC, MIP, MEP parameters were better (Çelik et al., 2021). It is a proven fact that strengthening respiratory muscles with the help of exercises results in increased exercise performance (Culver et al., 2017; Egan and Zierath, 2013; Lötters et al., 2002; Silva et al., 2019).

Conclusion

Generally, studies on inspiratory muscle training have been carried out for the purpose of rehabilitation of the patients with respiratory problems and performance improvement in sports. However, as result of this study, it was concluded that the inspiratory muscle training can improve respiratory muscle strength and lung functions of the sedentary individuals. Moreover, to increase the life quality and work force in healthy sedentary individuals and minimize the factors that affecting the formation of respiratory diseases, performing of the IMT-D can be recommended.

Ethics Committee Permission Information

Ethics review board: Niğde Ömer Halisdemir University Non-Invasive Clinical Research Ethics Committee

Date of ethics evaluation document: 04.11.2021

Issue number of the ethics evaluation document: 2021/89

Author Contributions

All authors read and approved the final version of the manuscript. The contributions of all authors have been described in the following manner:

Conception: Z.B.A., N.E.P., G.Y. conceived the original idea.

Performance of Work: Z.B.A., N.E.P., G.Y., S.K. conceived and planned the experimental settings required for data collection N.E.P., Z.B.A., G.Y., S.K. performed the measurements.

Interpretatıon or Analysis of Data: Z.B.A., S.İ.

Preparation of The Manuscript: Z.B.A., N.E.P., G.Y., S.K. took the lead in writing the manuscript Z.B.A. processed the experimental data, performed the analysis, drafted the manuscript.

Supervision: Z.B.A., supervised the project.

Conflict of Interest Declaration:

The author(s) did not have a conflict statement regarding the research.

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