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The Effect of Aerobic and Core Exercises on Forced Vital Capacity

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Authors' contribution:
A) conception and design of the study
B) acquisition of data
C) analysis and interpretation of data
D) manuscript preparation
E) obtaining funding

ABSTRACT

The aim of the study was to investigate the effect of aerobic and core strength exercises on forced vital capacity in sedentary women. A total of 40 healthy sedentary women (20 in an aerobic-step group and 20 in a core strength exercise group) with a mean age of 34.4±2.4 years participated voluntarily in this study. Two different exercises were applied to the women for 12 weeks, 4 days a week, at the intensity of 70% for 60 minutes. The women's resting heart rate (RHR), maximal oxygen consumption (VO_{2max}), forced vital capacity (FVC), and forced air volume in the first second of forced expiration (FEV1) were measured before and after exercise. For statistical analysis, the Paired Samples-t test was used for intra-group evaluations, and the Independent Samples-t test was used for inter-group evaluations. After the exercise program, significant increases were found in the VO_{2max}, FVC, and FEV1 values, while both groups experienced a decreased RHR ($p<0.01$). Since the aerobic and forced vital capacities of the sedentary women show a parallel increase as a result of the applied 12-week aerobic and core strength exercises, it can be said that the RHR, VO_2max, FEV, and FEV1 respiratory parameters also improved in a positive manner. For this reason, it may be advisable to apply both exercise types for the development of the aerobic and vital capacities of sedentary women.

KEYWORDS exercise, VO_2max, spirometer, sedentary woman

Introduction

Regular physical activity has both preventative and remedial effects for preventing chronic diseases and maintaining a healthy lifestyle (Hillsdon et al. 2005). Therefore, physical activity in women is important for a healthy lifestyle and maintaining highly physical functionalities during middle age; it is also important for the primal prevention of chronic diseases such as diabetes, diabetes mellitus, cardiovascular disorders, and respiratory disorders (Brown et al. 2007; Stadler et al. 2009; Badaam et al. 2013). However, physical exercise has many positive effects on respiratory functioning systems as it improves aerobic strength and reduces shortness of breath while also improving VO_{2max}, an indication of harmony between the cardiovascular and respiratory systems (Doijad et al. 2013; Fatima et al. 2013). The longitudinal changes in the VO_2 peak have been proposed to be associated with changes in lung function (Fatemi et al. 2012). Respiratory function depends on various factors, including the nervous system, the strength of the respiratory muscles, and the dimensions of the lungs (Azad et al. 2011).

Exercise improves the endurance and strength of the respiratory muscles of athletes, decreases resistance in the respiratory tract, and increases lung elasticity and alveolar expansion by promoting the expansion of pulmonary volumes and capacities (Khosravi et al. 2013). For this reason, the choice of appropriate exercise may be an important factor in preventing or reducing respiratory diseases and may increase the effectiveness of this system (Khosravi et al. 2013). While there have been many studies (Chandran et al. 2004; Nourry et al. 2005) that show that exercise significantly improves respiratory functions, some researchers have found that it has no effect (Jakes et al. 2002; Grisbrook et al. 2012).

A spirometer is an important instrument in the evaluation of the cardiovascular and respiratory functions. Forced Vital Capacity (FVC) and Forced Expiratory Volume in One Second (FEV1) are two indicators of strong respiratory function that weaken due to a sedentary lifestyle (Inselma et al. 1993; Jakes et al. 2002). There has been a study reporting a positive correlation between physical activity, physical fitness, and lung capacity (Khashaba 2015).

Prolonged aerobic and core strength exercises are thought to improve aerobic capacity and, consequently, to have a favorable effect on forced vital capacity. For this reason, this study was conducted to determine which of the 12-week aerobic and core strength exercises were effective in the forced vital capacity of sedentary women.

Method

Research Group:

The participants in this study were 40 healthy female volunteers aged between 30 and 40 years old (AVG: 34.4 ± 2.4). None of the participants had previously participated in any regular sports activities and did not smoke or have any chronic disorders, heart disease, or respiratory infections. An informed consent form prepared according to the Helsinki Declaration was signed by the women. Groups were randomly divided into two according to the aerobic exercise group (AE; n = 20) and core strength exercise group (CE; n = 20).

Physical Tests:

The height of the women was measured using a steel Mescon brand tape in meters (m) with a precision of 1 mm with the women's bare feet standing flat on the ground, heels adjoining, knees tense, and body in the vertical position. The body weight measurement was measured in kilograms (kg) on a scale with a precision of 0.01 kg provided that the women had bare feet and wore light clothes. The body mass index (BMI) formula (Body weight / Height^2) was used to determine the body mass index.

Metabolic Tests:

While resting heart rate (RHR) was measured using a portable heart rate monitor (Polar, Finland), the women's maximum heart rate (HRmax) was determined using the 220-AGE formula.

Physiological Tests

Determination of Maximal Aerobic Power ($VO2_{max}$):

This was tested using a 20 m shuttle run test, which shows cardiorespiratory efficiency and aerobic capacity (Tamer 2000). The Powertimer PC 1.9.5 Version Newtest tool was used for this purpose. Two photocells were placed at the start and finish points of the women's running track of 20 m. The women's running pace was determined by the pre-programmed tool and its periodic signal tones. For this, the woman waiting at the start will run to the photocell at the finish point with the sound of the signal and will reach the finish before the next signal is sent. When she hears the signal again, she will run to the start photocell. The $VO2_{max}$ value was determined in ml/kg/min based on the number of shuttle runs executed.

Respiratory Function:

The respiratory parameters were measured using the CSMI Spirometrics instrument. The subjects sat on a chair in a comfortable position. They were made to take the mouthpiece of the spirometer thoroughly and pegs were fit to the nose to prevent air leakage. Measurements were repeated three times at five-minute intervals, and the best grade was recorded.

Forced Vital Capacity (FVC):

This is the maximum air volume that is expired after a forcing, rapid, and deep expiration. FVC was recorded in liters.

Forced Expiratory Volume in One Second (FEV1):

This is the volume that is expired in the first second of forced expiration. In addition, the predicted (estimated) forced expiratory volume in one second was recorded in liters (FEV1-L).

Exercise intervention

During the exercises, the heart rate (HR) of both groups was controlled by a portable pulsimeter (Polar) device. In order to determine the severity of exercise in accordance with the Karvonen Method, the target HRs of each subject were separately calculated as follows:

Target HR = [(220 – AGE) – RHR] x 0.70 + RHR (Goldberg et al. 1988).

AE Group Exercise Program:

The women were given aerobic-step training for 60 minutes for 4 days a week for 12 weeks according to their designated target HR levels. Low-tempo warm-up exercises were done for 10 minutes, followed by 40-minute basic aerobic-step exercises, and finally 10-minute cooling exercises.

CE Group Exercise Program:

The women underwent a 60-minute core strength exercise for 4 days a week for 12 weeks according to their determined target HR levels. Basic 15-minute aerobic warm-up exercises, 35-minute core strength exercises, and 10-minute cool-down exercises were applied (Table 1).

Table 1: Core strength exercise program (Chabut 2009).

Exercise Program	Intensity	Core Exercise	Frequency
Warm–up (10 min)	RPE, 7–9		
Main exercise (35-40 min)	60%-70% 3 sets/10 repetitions/set, (1-2min resting interval)	Hip lifts with knee Crunches Side crunch Double crunch Reverse crunch Legs straight up crunch Side-lying crunch Half-up twists Bicycles Push-ups on knees Plank leg lifts Superman — opposite arm and leg extension Squats Side lunge, left and right	4 Times/wk
Cool-down (10 min)	RPE, 7–9	Stretching	

Source: Own study.

Statistical Analysis

The SPSS 19.0 statistical package program was used in calculating the data. The descriptive statistics are given as (X ± SD in the text by calculating the arithmetic mean (X) and standard deviation (SD) of the data. The normality test was carried out by using the Shapiro-Wilcoxon test, and parametric tests were applied. The Paired Samples-t test was used for intra-group evaluations and the Independent Samples-t test was used for inter-group evaluations. In this study, $p<0.05$ and $p<0.01$ was regarded as the significance level.

Results

When the physical and anthropometric values of the aerobic exercise group (AEG; n: 20) and core strength exercise group (CEG; n: 20) were examined in this study before the 12-week exercise program, age, height, bodyweight, and BMI were similar (Table 2).

Table 2: Anthropometric data (mean±SD)

Variables	AEG (mean±SD)	CEG (mean±SD)
Age (years)	33±2.7	35.8±2.23
Height (cm)	1.60±1.58	1.59±1.67
Weight (kg)	69.30±8.30	71.85±8.35
BMI (kg/m^2)	27.5±3.29	28.1±2.7

Source: Own study.

In our study, intra-group and inter-group comparisons of pre-exercise (PE) and post-exercise (POE) data of AEG and CEG applied for 12 weeks were examined (Tables 3 and 4).

Table 3: Intra-group values of the PE and POE variables of the groups

	AEG			CEG		
Variables	**PE (mean±SD)**	**POE (mean±SD)**	**P**	**PE (mean±SD)**	**POE (mean±SD)**	**P**
Rest HR (beats/min)	81.75±9.08	75.45±8.13	0.00**	82.95±7.83	76.75±7.24	0.00**
VO_{2max} (ml/kg/min)	25.28±1.17	32.33±3.42	0.00**	25.04±1.94	30.87±3.14	0.00**
FVC (L)	2.52±0.61	2.98±0.56	0.02**	2.99±0.57	3.15±0.5	0.03**
FEV1 (L)	2.21±0.52	2.67±0.6	0.01**	2.23±0.39	2.63±0.56	0.08**

***p <0.01 and * p<0.05*

Source: Own study.

When the intra-group evaluations of both groups before and after 12 weeks of exercise were examined, AEG's VO_{2max}, FVC, and FEV1 values were significantly increased, while the RHR value was significantly decreased ($p<0.01$). CEG's VO_{2max}, FVC and FEV1 values significantly increased, while the RHR value decreased ($p<0.01$).

Table 4: Inter-group values of PE and POE variables of the groups

Variables	Group	PE (mean±SD)	P	POE (mean±SD)	P
Rest HR (beats/min)	**AE**	81.75±9.08	0.657	75.45±8.13	0.597
	CE	82.95±7.83		76.75±7.24	
VO_{2max} (ml/kg/min)	**AE**	25.28±1.17	0.633	32.33±3.42	0.167
	CE	25.04±1.94		30.87±3.14	
FVC (L)	**AE**	2.52±0.61	0.160	2.98±0.56	0.329
	CE	2.99±0.57		3.15±0.5	
FEV1(L)	**AE**	2.21±0.52	0.913	2.67±0.6	0.823
	CE	2.23±0.39		2.63±0.56	

Source: Own study.

When the inter-group values of the AEG and CEG before and after the 12-week exercise program were examined, no significant difference was observed in the RHR, VO_{2max}, FVC, and FEV1 values ($p<0.05$).

Discussion

In this study, different exercise programs were applied for 60 minutes for 4 days a week for 12 weeks according to the determined target HR levels for similar AE and CE groups. The effects of aerobic capacity and forced vital capacity of sedentary women were examined according to the data obtained before and after the exercises. In order to determine which of the two different exercise types (AE and CE) applied to two similar groups (AEG and CEG) during 12 weeks is more effective, intra-group assessments were regarded as a reference rather than the inter-group assessments of the data obtained in the pre- and post- exercise periods.

Physical fitness depends mainly on the cardiorespiratory endurance of individuals. Since VO_{2max} is a widely known physiological parameter used in cardiovascular health and cardiorespiratory endurance measurement (Jacks et al. 2011; Pakkala et al. 2011; Doijad et al. 2013), in this study, the research group's VO_{2max} and RHR values were examined. In our study, both groups showed statistically significant improvements in their VO_{2max} and RHR values after 12-week AE and CE ($p<0.01$). Regularly followed 12-week aerobic and strength exercises can be said to increase VO_{2max} and cardiorespiratory endurance (De Backer et al. 2007; Lovell et al. 2009; Arazi et al. 2012). It can be stated that improvements in the RHR values of both groups showed positive decreases in heart rates due to increases in the power of the contraction of the heart and pulse volume because of regular training (Rodrigues et al. 2006; Donal et al. 2011; Molmen et al. 2012). This can be explained by the fact that both exercise types have an effect on sedentary women's VO_{2max} and RHR values.

Respiratory muscle strength is lower in sedentary women, and lacking pulmonary function is associated with a sedentary lifestyle (Simões et al. 2010). Although the respiratory functions are managed by genetic, environmental, and nutritional factors (Moradians et al. 2016; Akhade and Muniyappanavar 2014), their dynamic factors are dependent on various variables such as age, physical activity level, environmental pollution, body composition, and long-term lung disease (Moradians et al. 2016; Judith et al. 2007; Fatemi et al. 2012). Regular long-term physical exercises help improve the strength of respiratory muscles (Akhade & Muniyappanavar 2014), while good physical fitness is associated with better respiratory function (Pelkonen et al. 2003). Therefore, participation in certain physical activities or sports may lead to the strengthening of respiratory muscles, improvements in pulmonary functions, and achieving an effective pulmonary function (FVC, FEV1) (Prakash et al. 2007; Mahotra et al. 2016). When the respiratory function parameters of both groups of 12-week AE and CE results were examined in our study, significant improvements were observed in the FVC and FEV1 values of AEG and CEG ($p<0.05$). This may have been due to increased values of FVC and FEV1 (Farrell 1981), as regular 12-week aerobic and strength exercise programs are long enough to cause significant changes in lung function (Moradians et al. 2016). Different exercises, such as interval and high-intensity training programs, have shown that they can increase pulmonary respiratory functions (FVC and FEV1) (Nourry et al. 2005). However, it can be said that FVC has also developed in a positive direction because the exercises applied to the sedentary women are effective in improving respiratory muscles. Also, the increase in FVC for AEG relative to CEG may be due to the fact that the value of VO_{2max} shows more improvement in this group. There is a positive relationship between VO_{2max} and FEV1 and any increase in VO_{2max} is due to increases in FEV1 volume (Babb et al. 1997). Regular running and pilates aerobic programs may also have affected the development of lung functions and the cardiovascular system (Akhade & Muniyappanavar 2014; Mikalački et al. 2017) by increasing respiratory capacity and providing a positive effect on the lungs. Because of our 12-week exercise period, we can conclude that both exercise types have an effect on the FVC and FEV1 values of sedentary women.

Conclusion and recommendations

This study found that long-term aerobic exercise and core strength exercises in sedentary women developed RHR and VO_{2max} capacities and FEV and FEV1 respiratory parameters. It has also been found that aerobic capacity and forced vital capacity have developed parallel with each other. For this reason, both exercise types can be recommended to sedentary women to improve their aerobic and vital capacities.

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