Research Article

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The Effect of Six Weeks of Concurrent Training (Endurance-Resistance) on the Performance of the Cardio-Respiratory System in Inactive Young Women

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Abstract

Introduction: *Inactive lifestyle is associated with decreased cardiorespiratory function and increased chronic non-communicable diseases and death. The aim of this study was to investigate the effect of six weeks of concurrent training (endurance-resistance) on the performance of the cardio-respiratory system in inactive young women.*

Method: *In this quasi-experimental study, 16 inactive women of Tehran city were selected in a targeted and available manner and were randomly placed in two control groups [n = 8] and concurrent exercise [endurance and resistance] [n = 8]. After the pre-test [anthropometric tests and gas analyzer], the concurrent exercise group [endurance and resistance] performed the concurrent exercise program for six weeks and three sessions every week, and the subjects of the control group did not have any special exercise. After the six-week training period, measuring anthropometric indices [body mass index [BMI], body fat percentage [PBF], muscle mass [SMM] and hip-to-waist ratio [WHR] and cardiorespiratory indices including [the first ventilatory threshold [VE/VO2], Second ventilatory threshold [VE/VCO2], maximum oxygen consumption [VO2max], respiratory exchange ratio [RER], heart rate [HR], forced vital capacity [FVC], forced expiratory volume in one second [FEV1], expiratory volume forced in one second to forced capacity [FEV1/FVC] and the ratio of oxygen consumption to heart rate [VO2/HR] was done using in-body device and gas analyzer. The data were analyzed by covariance analysis test at the P<0.05.*

Results: *The results showed that six weeks of concurrent training [endurance-resistance] had no significant effect on the values of VO2max, FEV1, FVC, VE/VO2, VE/VCO2, FEV1/FVC, VO2/HR, HR in inactive young women [P<0.05]. Also, after the training period, there was no difference in BMI, PBF, SMM and WHR indices between the training and control groups [P<0.05].*

Conclusion: *According to the results of the research, it seems that six weeks of concurrent training [endurance-resistance] does not affect the performance of the cardio-respiratory system in inactive young women.*

Key Words: Concurrent Training, Cardio-Respiratory System, Inactivity

Introduction

The lack of regular physical activity and the high prevalence of inactivity increase the accumulation of visceral fat and, as a result, increase chronic low-grade inflammation and the onset of metabolic disorders, including metabolic syndrome, which shows a set of risk markers such as abdominal obesity, hyperglycemia, and hypertriglyceridemia. , low-density lipoprotein cholesterol, insulin resistance and pro-inflammatory state are strong and independent factors in the development of type 2 diabetes and cardiovascular diseases [1, 2]. In addition to negatively impacting metabolic health and cardiovascular disease, an inactive lifestyle also accelerates age-related decline in lung function, in turn, decline in lung function is associated with increased chronic noncommunicable diseases and death [3, 4].

Inactivity and physical inactivity are among the leading modifiable risk factors worldwide for cardiovascular disease and all-cause mortality. Promoting physical activity and sports training that leads to improved levels of cardiorespiratory fitness in all age groups, race, ethnicity, and both sexes is needed to prevent many chronic diseases, especially cardiovascular diseases [5]. Proposed mechanisms of cardiovascular pathophysiology caused by sedentary behaviors have been proposed. It is thought that the main driver of adverse cardiovascular effects from sedentary behaviors is venous pooling in the lower extremities as a result of reduced muscle activity and thus reduced muscle pump function [6]. A further hypothesis is venous pooling to reduce venous return and, in turn, stroke [7]. This reduction in stroke volume, along with increased hydrostatic pressure in the lower extremities and increased arterial tortuosity, creates a unique hemodynamic environment whereby Cardiovascular load may increase [8, 9]. It has been shown that acute inactivity can lead to impaired vascular function of the lower limbs, peripheral blood pressure and increased stiffness of the central and peripheral arteries [10, 11]. In addition to negatively impacting cardiovascular health, physical inactivity accelerates age-related decline in lung function and is associated with decreased lung function, chronic noncommunicable diseases, and death [4].

The positive effects of regular exercise on health-related outcomes are widely recognized in all age groups [5]. Physical activity plays an important role in the primary and secondary prevention of many chronic diseases such as cardio-respiratory, metabolic and cancer diseases, as well as premature mortality [12]. Previous studies have shown that regular participation in sports activities can improve cardio-respiratory fitness and body composition [13]. In this context, performing aerobic and strength exercises simultaneously [concurrent exercises] is an integral part of physical exercises that are performed with the aim of improving sports performance and health. Concurrent or simultaneous exercises refer to the combination of aerobic and strength exercises to create aerobic capacity and muscle strength or hypertrophy at the same time [14]. It is important to recommend both aerobic and strength training because these activities induce some degree of adaptation and distinct health benefits. Aerobic exercise increases aerobic capacity [meaning central adaptations] and metabolic changes in skeletal muscles, such as increasing mitochondrial density and increasing capillaries in the muscle; Conversely, regular resistance training leads to muscle hypertrophy, increased strength and power, and may also improve bone mineral density [15]. Concarnet exercises improve some cardio-respiratory indicators. In the same context, the results of Eschuman et al. [2015] showed that the maximal oxygen consumption in men and women was statistically higher in concurrent exercises [endurance and strength at the same time] compared to endurance and strength exercises alone [16]. Parestesh [2018] in a research showed that 12 weeks of simultaneous training resulted in a significant decrease in the percentage of fat mass and the ratio of waist to hip circumference and a significant increase in cardio-respiratory endurance [VO2max], average relative muscle strength and fat-free mass in the simultaneous training group compared to the control group did not exercise [17]. Shabani et al. [2016] also showed in a research on inactive postmenopausal women that combined exercise with improving cardio-respiratory endurance can be effective in preventing cardiovascular diseases [18]. However, some studies have shown that a combination of endurance and strength training in a training program when the total number of weekly training sessions is high leads to impaired strength development and muscle hypertrophy [19]. One study has shown that VO2max decreases after a long period [20 weeks] of concurrent endurance and strength training in men [20]. Gabler et al. [2018] also observed that compared to endurance training or strength training alone, concurrent training produced slight beneficial effects on cardiorespiratory endurance in young athletes [21].

As mentioned, inactive lifestyle is associated with a high risk of increasing cardio-respiratory diseases. Doing regular sports exercises is considered as an effective treatment path in reducing cardio-respiratory diseases, especially in sedentary men and women; Considering today's modern life and the relative decrease in daily physical activity and the occurrence of some diseases related to weight gain and lack of physical fitness, research on the positive effects of exercise on the cardiorespiratory system and the use of appropriate exercise methods are essential to It seems But based on the researcher's studies, the research done in this regard is very limited. On the other hand, according to the investigations and previous studies, the effect of concurrent exercises [endurance-resistance] on the performance of the cardio-respiratory system of inactive women is not well known, and from this point of view, the researcher's research is of great importance. Therefore, the current research aims to investigate the effect of concurrent exercises [endurance-resistance] on the performance of the cardio-respiratory system of inactive women.

Method

The present study is a semi-experimental study. The statistical population of this research is made up of 30 women registered in a club, located in the Panj district of Tehran, who are in the age range of 20 to 35 years and have not had regular physical exercise in the past year. After completing the questionnaire by 25 members of the club, the researcher, by checking the height, weight, age and physical health of the subjects according to the completed questionnaires, the number of 16 people who are in the age range in terms of health the eligible subjects were selected, then they were randomly divided into two control groups [N=8] and training group [N=8] and consent was obtained from all the subjects. The sample size of the present study was determined based on the results of previous research, at a significance level of 5% (type 1 error) and statistical power of 95% [type 2 error] using Medcalc 18.2.1 software [8 people in each group]. All the subjects eligible to participate in the test submitted the written consent form and the relevant questionnaire one week before the start of the research and declared their readiness to start the training program. A briefing session was held with the presence of the researcher to familiarize the subjects with the method of conducting the research, the day and time of the protocol and other explanations. After randomly dividing people into two training and control groups, 24 hours before the start of training, anthropometric measurement, body composition and breath gas test [gas analyzer] were performed on all subjects, and they were advised to refrain from vigorous physical activity during these 24 hours. Avoid and do not eat heavy food within an hour before the test. The criteria for entering the research include; in the past one year, they have not had any continuous exercise and only moderate daily activity, they have no history of lung and allergic disease, they do not smoke, they are in the age range of 20-35 years, they do not have physical limitations to exercise. The criteria for exiting the research include; Failure to sign a written consent form, absence of more than one session in the training program, injury, failure to attend the test, and unwillingness to continue participating in the training program. The training program was implemented for 6 weeks and on odd days [Sunday, Tuesday, and Thursday] and the subjects of the control group did not have any special training. After 6 weeks, 24 hours after the last training session, the subjects were tested in the same way as the pre-test; It should be noted that the interpretation of all these tests was done at the National Olympic Academy.

Exercise Protocol

Each training session consisted of: warm-up, main exercise and cool-down. To warm up the body, butterfly movements, high knees, lunges, burpees, squats, and Japanese greetings were performed for 10 minutes. To cool down the body, various stretching movements were performed for 10 minutes. The control group consisted of 8 people who did not do any sports activities until the end of the research.

Table 1: Exercises were performed according to the following table:

Week 5-6 Rest for 30 seconds	Week 3-4 Rest for 45 seconds	Week 1-2 Rest for 60 seconds	Practice 1-6 weeks in total
Repetition: 4 Round: 3(5), 4(6)	Repetition: 3 Round: 2 (week 3), 3 (week 4)	Repetition: 2 Round: 2	9 meter jum
Repetition: 4 Round: 3(5), 4(6)	Repetition: 3 Round 2(3), 3(4)	Repetition: 2 Round: 2	Agility ladder (inside, inside - outside, outside)
Repetition: 4 Round: 3(5), 4(6)	Repetition: 8 Round: 2(3), 3(4)	Repetition: 5 Round: 2	Weightlifting double
Repetition: 1 Round: 3(5), 4(6)	Repetition: 1 Round: 2(3), 3(4)	Repetition: 1 Round: 2	Climbing movement 9 meters with an 8 pound medicine ball
Repetition: 1 Round: 3(5), 4(6)	Repetition: 8 Round: 2(3), 3(4)	Repetition: 5 Round: 2	ROW movement with the TRX strap
Repetition: 1 Round: 3(5), 4(6)	Repetition: 8 Round: 2(3), 3(4)	Repetition: 5 Round: 2	Medicine ball throw from above the head
Repetition of the fifth week: 5 Repetition of the sixth week: 6 Work to rest ratio: 15 seconds to 15 seconds	Repetition of the third week: 5 Repetition of the fourth week: 6 Work-rest ratio: 10 seconds to 20 seconds	Repetition of the first week: 4 Repetition of the second week: 5 Ratio of work to rest: 10 seconds to 30 seconds	In the end: the stationary bike

A respiratory gas analyzer was used to determine respiratory gases. Maximum oxygen consumption [VO2MAX], produced carbon dioxide [VCO2], minute ventilation [VE], first ventilation failure point (VT1), Second ventilatory failure point [VT2], respiratory exchange ratio [RER], heart rate [HR], ratio of oxygen consumption to heart rate[(VO2/HR] were measured breath by breath during the treadmill protocol. Polar heart rate monitor belt was used to record moment-to-moment changes in subjects' heart rate during the Bruce test.

Statistical Method

The Shapiro-Wilk test was used to determine the normality of data distribution. Then, analysis of covariance and independent t-test were used to compare the groups. Calculations were done using SPSS version 26 statistical software and the significance level of the tests was considered as $p \leq 0.05$.

Results

Tables 1 and 2 show the results of descriptive statistics related to the demographic characteristics of the subjects and research variables between different research groups.

Table 1, the results of descriptive statistics related to the average demographic characteristics of the subjects

control group		Practice group		variable group
After the test	pre-test	After the test	pre-test	
---	18/9±3/26	---	30/6±5/27	age (years)
---	11/5 ± 165	---	28/7 ± 166	height (cm)
2/9±3/66	08/8±4/66	62/14±4/67	40/15±3/67	weight (kg)

Table 2-4: Description of research variables

control group		Practice group		variable group
After the test	Pre-test	After the test	pre-test	
25/16 ± 2/03	25/17 ± 2/06	26 ± 2/18	25/05 ± 3/16	VE/VO2
28/93 ± 1/29	28/85 ± 1/36	30/06 ± 3	28/83 ± 3/11	VE/VCO2
21/25 ± 2/43	21/87 ± 3/13	20 ± 3/85	19 ± 2/82	VO_{2max}
0/877 ± 0/041	0/878 ± 0/043	0/875 ± 0/07	0/877 ± 0/11	RER
153/12 ± 2/18	153/75 ± 3/01	148/75 ± 12/88	151/25 ± 8/06	HR
3/86 ± 0/13	3/89 ± 0/15	4/13 ± 1/05	4/02 ± 0/85	FVC
2/76 ± 0/15	2/78 ± 0/17	2/89 ± 0/39	2/78 ± 0/34	FEV1
0/707 ± 0/03	0/703 ± /03	0/73 ± /12	0/71 ± 0/12	FEV1/FVC
8/25± 0/70	8/12 ± 0/83	8/87 ± 1/64	8/37 ± 1/50	VO2/HR
28/16 ± 0/74	28/11 ± 0/80	24/21 ± 4/52	24/22 ± 4/67	BMI
25/16 ± 1/59	25/26 ± 1/05	33/28 ± 7/82	33/68 ± 8/93	PBF
27/40 ± 1/04	27/61 ± 1/25	23/82 ± 3/25	23/66 ±3/25	SMM
0/907 ± 0/043	0/905 ± 0/035	0/90 ± 0/10	0/91 ± 0/13	WHR

For factors VE/VCO2 [p = 0.60], VO2max [p = 0.14], RER [p = 0.22], FVC [p = 0.86], FEV1 [p = 0.18], FEV1 /FVC [p = 0.70], VO2/HR [p = 0.54], BMI [p = 0.56], PBF [p = 0.2] and SMM [p = 0.082] because the principle of homogeneity The regression slope was established, the analysis of covariance test was used, and for the factors VE/VO2 [p = 0.034] and WHR [p = 0.032], since the principle of homogeneity of the regression slope was not established, the independent t test was used.

The results of the independent t-test showed that VE/VO2 [p = 0.078] and WHR [p = 0.25] did not have a significant difference between the two groups.

Table 4-3: Independent t-test results related to VE/VO2 and WHR in two groups

intergroup		Intergroup		Time	variable
t	P	t	P	Groups	
2/01	0/078	-2/06	0/078	Practice	VE/VO2
		0/10	0/92	Control	
-1/19	0/25	1/07	0/32	Practice	WHR
		-0/552	0/59	Control	

The results of the analysis of variance statistical test showed that time [p = 0.66] and the interaction of time and group on VO2max [p = 0.197] had no significant effect. Time [p = 0.91] and the interaction of time and group [p = 0.97] had no significant effect on RER. Time [p = 0.062] and the interaction of time and group [p = 0.31] had no significant effect on HR. Time [p = 0.73] and the interaction of time and group [p = 0.56] had no significant effect on FVC. Time [p = 0.63] and interaction between time and group [p = 0.51] had no significant effect on FEV1. Time [p = 0.49] and interaction between time and group [p = 0.58] had no significant effect on FEV1/FVC. Time [p = 0.16] and the interaction of time and group [p = 0.219] did not have a significant effect on the second ventilation failure point. Time [p = 0.053] and interaction between time and group [p = 0.22] had no significant effect on VO2/HR. Time [p = 0.74] and the interaction of time and group [p = 0.58] had no significant effect on BMI. Time [p = 0.46] and the interaction of time and group [p = 0.65] had no significant effect on PBF. Time [p = 0.80] and the interaction of time and group [p = 0.081] had no significant effect on SMM.

Table 5-4: The results of the covariance analysis test related to the research variables in the subject groups

	Source of changes	sum of squares	Degrees of freedom	Mean of squares	F Value	p Value
VO_{2max}	time	0/281	1	0/281	0/197	0/66
	The interaction of time and group	5/28	1	5/28	3/70	0/075
RER	time	2/81	1	2/81	0/012	0/914
	The interaction of time and group	3/12	1	3/12	0/001	0/971
heart rate (HR)	time	0/838	1	0/819	4/31	0/062
	The interaction of time and group	0/361	1	0/324	1/77	0/312
FVC	time	0/014	1	0/014	0/121	0/734
	The interaction of time and group	0/039	1	0/039	0/347	0/565
FEV1	time	0/018	1	0/018	0/238	0/633
	The interaction of time and group	0/034	1	0/034	0/446	0/515
FEV1/FVC	time	0/002	1	0/002	0/610	0/448
	The interaction of time and group	0/001	1	0/001	0/323	0/579
VE/VCO2	time	3/44	1	3/44	2/20	0/16
	The interaction of time and group	2/58	1	2/58	1/65	0/219
VO2/HR	time	0/781	1	0/781	4/48	0/053
	The interaction of time and group	0/281	1	0/281	1/61	0/224

Body Mass Index (BMI)	**time**	**0/003**	**1**	**0/003**	**0/111**	**0/744**
	The interaction of time and group	**0/008**	**1**	**0/008**	**0/309**	**0/587**
percentage of body fat (PBF)	**time**	**0/500**	**1**	**0/500**	**0/581**	**0/459**
	The interaction of time and group	**0/180**	**1**	**0/180**	**0/209**	**0/654**
Muscle Mass (SMM)	**time**	**0/005**	**1**	**0/005**	**0/063**	**0/806**
	The interaction of time and group	**0/281**	**1**	**0/281**	**3/53**	***0/081***

Discussion

The findings of the present research showed that concurrent [endurance-resistance] exercises lead to non-significant improvements in forced vital capacity [FVC], forced expiratory volume in one second [FEV1] and forced expiratory volume in one second to forced capacity [FEV1/FVC] and maximum oxygen consumption [VO2MAX] was disabled in young women. Also, after the training period, there was no significant change in the first ventilation break point [VT1], second ventilation break point [VT2], respiratory exchange ratio [RER], heart rate [HR], ratio of oxygen consumption to heart rate [VO2/HR] in Inactive young women were observed. The effect of concurrent [endurance-resistance] exercises on the cardiorespiratory function of sedentary people has been limited. It depends on physical fitness [22]. It can be said that the effectiveness of exercise training is due to improving the strength and endurance of the respiratory muscles, reducing inflammation and subsequently reducing the resistance of the airways. These factors will reduce the apparent resistance of ventilation and will allow to increase efficient ventilation with less effort. Increasing the strength of respiratory muscles and reducing airway resistance during exercise is effective in improving lung function. In explaining the reasons for the effect of exercise on FVC and FEV1 following exercise, it should be said that the weakness of respiratory muscles including the diaphragm, muscles between Ribs and abdominal muscle groups change the values of FVC and FEV1 and forced expiratory volume in one second to forced capacity, as well as increasing The remaining volume as a result of expiratory muscle weakness and neuromuscular disorders along with reduced lung elasticity and limited are among the factors that reduce FVC values. On the other hand, it has been found that neuromuscular coordination and greater activity of the diaphragm muscle improve these components [23]. Therefore, aerobic training has probably led to the improvement of these indicators through the above mechanisms, however, a longer training period may be needed to have a significant effect on these indicators.

VO2max, also known as functional aerobic capacity, indicates the maximum amount of oxygen used by exercising muscles and is considered the gold standard measure of the functional limitation of the cardiorespiratory system. The results of the current research indicated a non-significant improvement of VO2max after concurrent exercise [endurance and strength at the same time]. The findings of Gabler et al. [2018], Faton et al. [2010], Eschuman et al. [2015] and Prastesh [2018] have reported a significant increase in VO2max after concurrent exercise [endurance and strength at the same time] [16, 17, 21, 24].

Among the possible reasons for this increase in the maximum level of oxygen consumption, we can mention an increase in blood volume, an increase in the end-diastolic diameter, a better blood flow to the active muscles, an increase in the density of capillaries and mitochondria in active muscles after exercise [25]. Maximum oxygen consumption is significantly influenced by several factors such as genetic structures, growth, body composition and physical activity [26]. Also, the increase in maximum oxygen consumption can be due to the decrease in body fat percentage. Lean tissue is much more metabolic than adipose tissue. An increase in the ratio of lean tissue to fat is associated with an increase in the relative maximum rate of metabolism even in the absence of exercise [27]. Contrary to the findings of our study, some studies have shown that a combination of endurance and strength training in a training program when the total number of weekly training sessions is high leads to impaired strength development and muscle hypertrophy [19]. One study has shown that VO2max decreases after a long period [20 weeks] of concurrent endurance and strength training in men [20]. The inconsistency of the obtained results may be due to the different methods used. Even in some cases, the different conditions of the subjects in terms of age, gender and level of physical fitness may be effective in the heterogeneous results. Factors affecting RER during exercise, such as duration and intensity of exercise, age, sex, fitness level, muscle glycogen, and daily dietary intake, together explain only 60% of the variation in RER during exercise, and usual dietary intake Food has a greater effect on RER than carbohydrate consumed during exercise. More research is needed in women, especially regarding the RER response to exercise. It also appears that there is individual variation in substrate oxidation during exercise in both untrained and trained subjects [28, 29].

It has been found that during exercise, the increase in sympathetic activity causes the release of adrenaline and noradrenaline, resulting in an increase in myocardial contractions and an increase in heart rate. During exercise, by increasing the mean arterial pressure, the pressure receptors in the arteries by sending a negative feedback decrease the sympathetic activity and as a result increase the diameter of the vessels, increase the volume of blood available to the muscles, decrease the blood pressure and decrease the heart rate [30]. Exercise is accepted as a way to lose weight and improve body composition [31]. In the present study, a non-significant decrease in enterometric indices was observed. As a result of aerobic and resistance sports activities due to increased mitochondrial density, the capacity of oxidative enzymes increases in muscles. In addition, increasing the activity of the electron transfer chain enzymes increases the activity of enzymes involved in the oxidation of fats and also the activity of lipoprotein lipase [32]. As a result of aerobic training, the density of beta-adrenergic receptors on the cellular surface of fat tissue increases and as a result their sensitivity to the lipolysis process increases. It seems that the main driver of this process is the distribution of catecholamines due to aerobic activity and increased oxidation of fats. [33]. Therefore, the body weight of the subjects decreases. In the research of Sarmidian and Sohri [2015], 10 weeks of aerobic activity [with an intensity of 65 to 75% of the maximum heart rate] and resistance [with an intensity of 55 to 65% of one repetition maximum] with moderate intensity had no effect on weight in postmenopausal women. They stated that the reason its possibility can be caused by insufficient intensity and duration of exercises to create desirable changes [34]. It is possible that the intensity of the exercises in the present study was not suitable for weight loss. It is possible that concurrent exercises can lead to a greater reduction of fat percentage and improvement of muscle mass, especially in obese subjects, by activating fat tissue more and affecting the enzymes involved in fat metabolism compared to endurance and resistance exercises alone. Perhaps the most common reason and mechanism for justifying the improvement of body composition, the reduction and improvement of muscle mass as a result of resistance training is that following the stimulation of muscle protein synthesis and the increase of fat-free body mass as a result of resistance training, the rate of resting metabolism increases and this causes an increase in total energy consumption. Resting time and negative change in energy balance and therefore reducing fat and its total reserves in the body [35]. Therefore, adding this type of training to endurance training will probably bring more benefits. Generally, it is possible to reduce WHR with long-term and hard training. The lower the intensity and duration of exercise, the smaller the decrease in WHR [36]. Therefore, it may be interpreted that the intensity and duration of the exercises of the current protocol were not enough to significantly reduce WHR. One of the limitations of the present study is the small number of samples, so a similar study with the measurement of these indicators in a high number of samples is suggested. Also, future studies should consider a longer period of time and a higher intensity to investigate the pulmonary function response to concurrent exercise.

Conclusion

In summary, the results of this research showed that six weeks of concurrent exercises led to non-significant improvements in some cardiorespiratory indices in inactive women. According to the results of the present research, it seems that concurrent exercises can help improve cardiorespiratory function in inactive women. Therefore, inactive people, especially inactive women, can do this type of exercise to improve cardiorespiratory fitness. However, it is possible to achieve more cardiorespiratory benefits by performing concurrent exercises with greater intensity and duration.

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