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Effects of Eight Weeks of Circuit Resistance Training on Pulmonary Function of Inactive Women

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ABSTRACT
Effects of endurance training on respiratory system is approved somehow, but few and contradictory evidence exist concerning resistance training (RT), so the purpose of this research was therefore to study the effects of eight weeks of circuit RT (CRT) on pulmonary function of inactive women. Nineteen volunteer healthy inactive women were randomly divided into 2 groups: without training as the control (C) and CRT. A spirometry test was taken 24 h before and after the training course. The training period (8 weeks, 3 sessions/week) for CRT involved two circuits/session, 40-60s for each exercise with 60-80% of one the repetition maximum (1RM), and 1 and 3 min active rest between exercises and circuits, respectively. ANCOVA test showed that CRT increased significantly ($p<0.05$) maximum voluntary ventilation (MVV), peak expiratory flows (PEF), forced expiratory flows 25%-75% (FEF 25%-75%), and forced expiratory volume in one second (FEV1); but, vital capacity (VC), forced vital capacity (FVC), and FEV1/FVC ratio didn't change significantly. The results may suggest that the CRT can improve some pulmonary function factors of healthy young inactive women besides other benefits of this type of training for women.
Key Words: Circuit Resistance Training, VC, FVC, MVV, PEF, FEV1, FEF 25%-75%.

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INTRODUCTION

Sedentary lifestyle is associated with less efficient pulmonary function (1), and so ability of respiratory system and pulmonary function has a direct relationship with general health (2). Furthermore, regular physical activity is of much importance for young people's general health (3, 4). Since cardiorespiratory endurance is a key component of physical fitness and regular physical activity can lead to physical fitness improvement, it can enhance cardiorespiratory endurance (5). It is well documented that the most effective factor in cardiorespiratory fitness is physical activity level (6-8). Exercise training improves endurance and strength of athletes' respiratory muscles; it also causes a reduction in resistance of respiratory canals and increases lung elasticity and alveolar expansion, as studies have supported the expansion of pulmonary volumes and capacities (9). Accordingly, selection of appropriate type of exercise training may be an important factor in preventing or decreasing respiratory diseases and increasing the efficacy of this system.

Although some evidence has reported that the pulmonary system is unaffected by physical activity (10, 11). It is mainly recommended in various studies that endurance training (ET) is appropriate for improvement of pulmonary function (12), whereas some believe that fatigue of respiratory muscles has no influence on submaximal exercise functions. Others have found that body endurance is increased with respiratory trainings (13). On the other hand, RT has been found to have positive impacts on inspiratory and expiratory muscles, both in healthy people and individuals with chronic obstructive pulmonary disease (COPD) (12, 14-16). Few studies have been conducted on healthy individuals regarding the effect of inspiratory muscle training (IMT) (15) and concurrent respiratory muscle training (CRMT) (14) on pulmonary function and contradictory results have been reported in the studies which do exist.

In addition, because of religious behaviors of Iranian women, they have poor situations for active lifestyle. It can put them at risky situation of health, even though they are healthy. In the light of few studies on the effect of RT (17) but not on healthy subjects specially healthy inactive women, as well as contradictory results of these evidence, we purposed to examine the effects of CRT on VC, FVC, MVV, PEF, FEV1, and FEF 25%-75% of healthy inactive women.

MATERIAL and METHODS

Subjects. The present study was approved by the Research Ethics Committee of the School of Medical Sciences of Tarbiat Modares University (Iran), and conducted in accordance with policy statement of the Declaration of Iranian Ministry of Health. Written informed consent was obtained from 19 young healthy women. All subjects were asked to complete a medical examination as well as a medical questionnaire to ensure that they were not taking any regular medications; free of cardiac, respiratory, allergic, eye, and ear surgery; respiratory epidemic infections, uncontrolled blood pressure, thorax surgery history in three weeks before beginning trainings, history of pulmonary embolism, active hemoptysis, unstable angina, and myocardial infarction. The volunteers were assigned randomly to 2 groups including a control group (n=9) without training (C) and circuit RT (CRT) group (n=10).

Research Design. Participants were taken to the gym two times before the beginning of training period. In the first session, their 1RM was determined for each of 8 exercises. In the next session, a spirometry test was performed on each participants (spirometer: Spiro lab, SN: A23-050-7460, Mir Co, Italia) for VC, FVC, FEF

25%-75%, FEV1, FEV1/FVC ratio, PEF, and MVV measurements. The training sessions started in 24 h after the spirometry test for a period of 8 weeks with 3 sessions per week on Saturday, Monday, and Wednesday.

Exercise Training Procedure. The subjects were instructed to follow a normal lifestyle, maintain daily habits, and avoid any regular medications. Each session contained 10 min of warm-up and cool down. CRT training included two circuits/session, 60s (about 12 repeats) for each exercise with 60-65% 1RM, and 1 and 3 min active rest between exercises, and circuits, respectively during the first 4 weeks; and four circuits/session, 40s (about 8 repeats) for each exercise with 65-80% 1RM and same rest periods during the second 4 weeks (Table 1).

Table 1. **Summary of Resistance Training Procedures**

Period (weeks)	**Intensity** (1RM)	**Volume** (circuits/session)	**Frequency of exercises** (second/replicate)	**Rest** (min) between exercises	**Rest** (min) between circuits
1st **four**	60-65%	2	60 / 12	1	3
2nd **four**	65-80%	4	40 / 8	1	3

Statistics. ANCOVA was used to determine the effects of the mentioned training at a significance level of $p = 0.05$. Important ANCOVA assumptions, including linear relationship of dependent variable and covariate, normal distribution, and equality of error variances were examined with Pearson's correlation test, one-sample Kolmogorov-Smirnov test, and Levene test, respectively.

RESULTS

General data of the subjects including age, height, and weight are summarized in Table 2.

Table 2. **Descriptive statistics of subjects (Mean ± SE)**

Factors / **Groups**	**Age** *(Year)*	**Height** *(m)*	**Weight** *(kg)*
RT	26.4 ± 1.22	163.2 ± 1.46	59.3 ± 2.39
C	26.55 ± 0.94	161.88 ± 1.09	64.11 ± 2.94

RT: resistance training. **C:** control without training.

Assumptions of linear relationships and normal distribution were met in all variables. In ANCOVA results, the adjusted mean of dependent variables (post-test in this study) are presented with omission of covariate (pre-test in this study) effects.

VC, FVC, and FEV1/FVC. There was no significant difference between groups in terms of VC, FVC, and FEV1/FVC [($F = .001$, $p = .98$), ($F = 2.522$, $p = .132$) and ($F = 1.426$, $p = .25$), respectively] (table 3).

FEV1. The main effect of "Group" for FEV1 was significant ($F = 6.619$, $p = .02$). Mean plus-minus standard error of mean (M ± SE) of CRT (3.23 ± .06) was significantly greater than C (3.00 ± .06) (Fig. 2).

MVV. Differences between group for MVV were significant ($F = 13.707$, $p = .002$). M ± SE of CRT (83.46 ± .49) was significantly greater than C (80.75 ± .52) (Fig. 2).

FEF 25%-75%. Differences between group for FEF 25%-75% were significant (F = 7.673, p = .014). M ± SE of CRT (3.66 ± .06) was significantly greater than C (3.4 ± .06) (Fig. 2).

PEF. The main effect of "Group" for PEF was also significant (F = 4.35, p = .049). M ± SE of CRT (7.5 ± .07) was significantly greater than C (7.1 ± .08) (Fig. 2).

Table 3. **Post-test adjusted Mean of pulmonary function parameter (Mean ± SE)**

Factors Groups	VC *(Lit)*	FVC *(Lit)*	FEV1/FVC *(Ratio)*
RT	3.066 ± 0.05	3.79 ± 0.07	85.49 ± 0.5
C	3.068 ± 0.05	3.62 ± 0.07	84.33 ± 0.48

VC: Vital Capacity. **FVC:** Forced Vital Capacity. **FEV1/FVC:** Forced Expiratory Volume in one second (FEV1) to Forced Vital Capacity (FVC) ratio. **RT:** resistance training. **C:** control without training.

DISCUSSION

In this study, VC (equal to sum of expiratory reserve volume, inspiratory reserve volume, and flowing volume), FVC (i.e. maximum amount of air exited from lung with a deep expiration after a deep inspiration), and FEV1/FVC (i.e. the percentage of FVC which exits the lung during first second of a deep expiration) of CRT weren't different from C, but FEV1 (volume in 1st second is volume of air that exits the lung in 1st second of a deep and potent expiration), MVV (total volume of air replaced with inspiration and expiration in maximum depth and speed), FEF 25%-75%, and PEF (maximum volume of air flow during a deep expiration maneuver) of CRT were significantly greater than C.

Nourry *et al* (2005) reported a significant increase in FVC, PEF, and FEV1 of healthy prepubescent children after 8 weeks of high-intensity interval running training (18). Farid *et al* (2005) found significant elevation in FVC, MVV, PEF, FEF 25-75%, and FEV1, but FEV1/FVC showed no significant change after eight weeks of aerobic exercise (asthmatic patients, 3sessions/week, 20min/session, 15min warm up and tensile exercise before main exercise/session) (19). Tartibian, Maleki, and Abbasi. (2010) found a significant rise in VC, FVC, MVV, FEF 25-75%, and FEV1 after wrestling training (12 weeks, 3times/week, 90–120 min/day to 70–85% of HR_{max} in the first 6 weeks, and to 85–95% of HR_{max} in the second 6 weeks) (20). Cheng *et al* (2003) showed that active persons had a higher FEV1 than others (21). Besides, Wright *et al* (2003) after a hypertrophic maximal strength training [12 weeks (2 weeks of muscle habituation training, 5 weeks of hypertrophic training I, 5 weeks of hypertrophic training II with intensified eccentric work), initially twice, then 3 times a week, 60-120 min] in patients with chronic obstructive pulmonary disease (COPD) observed that FEV1 is elevated (5.3%) significantly compared to the baseline (12). Galvan and Cataneo (2007) believe that MVV can indicate the function of only respiratory muscles and therefore, the values of MVV increase on account of improved strength of inspiratory muscles (22). But we know that MVV is maximum voluntary ventilation and not only respiratory muscles but also expiratory muscles are involved in voluntary ventilation with strength; so depending on the capacity that inspiratory and expiratory muscles have to generate force, strength of these muscles is improved due to 8 weeks of CRT.

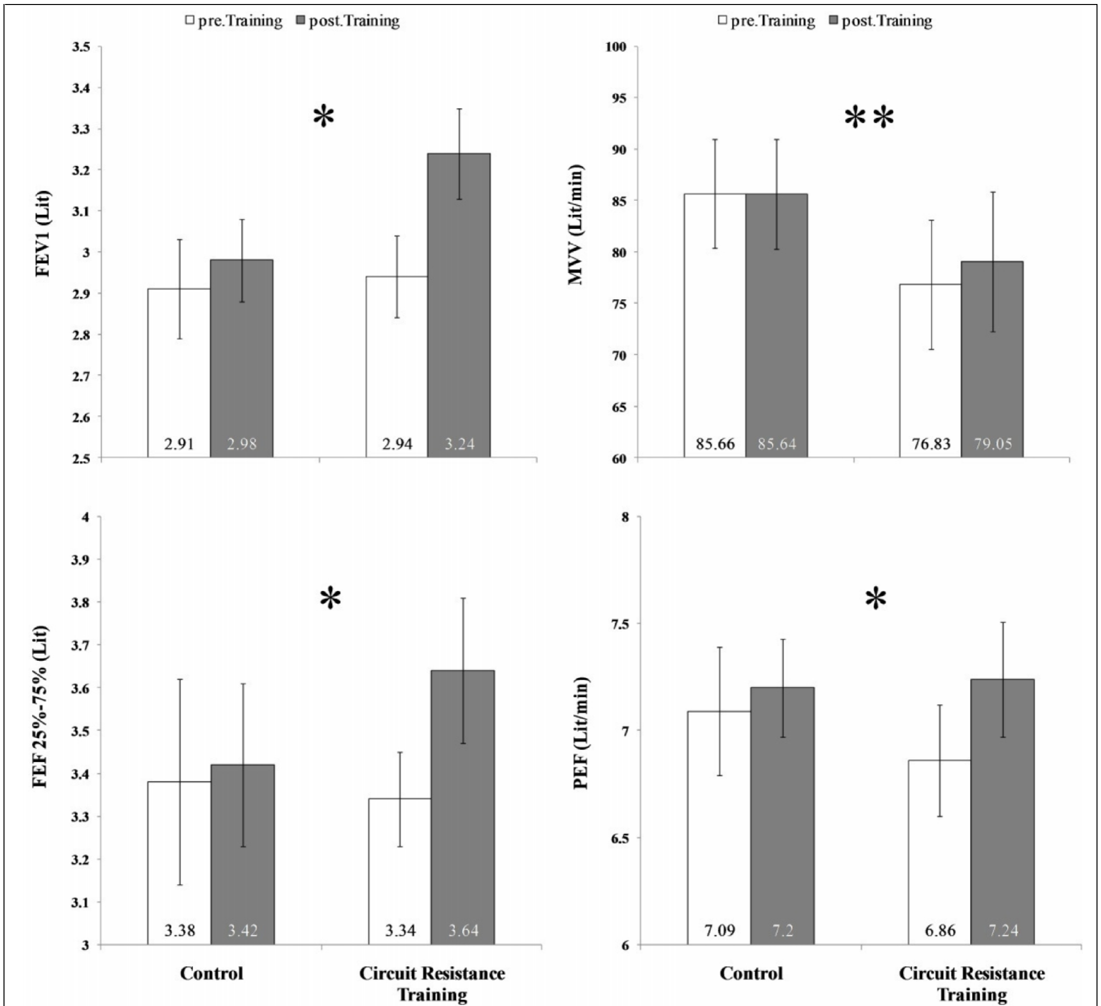

Figure 1. ***Pulmonary function differences in control and circuit resistance training groups.*** **FEV1:** Forced Expiratory Volume in one second. **MVV:** Maximum Voluntary Ventilation. **FEF25%-75%:** Forced Expiratory Flows. **PEF:** Peak Expiratory Flows. ***:** significantly different from Control group ($p < 0.05$). ****:** significantly different from Control group ($p < 0.01$).

Nourry *et al* (2005) (18), based on literature, interpreted that the improvement in expiratory flow parameters including PEF, FEF 25%-75%, FEV1, and FEV1/FVC could be illustrated by one or both causes: an increase in contractility (23) or strength (24, 25) of the expiratory muscle, or alterations in the lung compliance and the balance in airways resistance (24, 26), as described in introduction. Tartibian *et al* (2010) concluded that these variables were influenced by exercise training because in inactive control group they showed a significant decrease following 12 weeks of detraining (20). Besides, development of strength is related to increase in synthesis of the contractile proteins (actin and myosin) due to long-term training programs. Various studies suggest that the capacity of respiratory muscles can be elevated through appropriate stimuli that enlarge their workload and therefore the training of respiratory muscles through multiple types of exercise training purposes to expedite these kinds of cellular changes in the activated muscles (22).

Multiple aspects may support improvement of the pulmonary function. We know that muscular imbalances-associated with inactivity causes a restriction in the thorax (12), and so exercise training maybe could have a compensatory effect on this situation; furthermore, reinforcement of the auxiliary respiratory muscle is another effect of regular exercise training (27). It has been shown in previous studies on asthmatic patients that physical exercise can increase the residual air flow and decrease the ventilation with reinforcement of bronchi expansion during an exercise. This makes an asthmatic patient save air flow during exercise (19, 28).

In addition, improved pulmonary function following exercise training could be due to decreased airway resistance, increased airway caliber, and strengthened respiratory muscles as well as lung and thorax elasticity (9, 20). On the other hand, hormonal effects, compromised roles of adrenaline (29, 30) and cortisol (31) also appear to be feasible. A decreased lung retractability and induced vasodilatation of pulmonary vessels is reported due to an increased activation of adrenaline system during exercise training that vasodilatation of pulmonary vessels cause a decreased airway resistance and an enhanced FEV1 and FVC through increasing the airflow (29, 30). Serum cortisol has also been reported to have a connection to bronchodilatation and lung surfactant generation (31).

CONCLUSION

The present study showed that a period of CRT causes a clear increase in FEV1, MVV, FEF 25%-75%, and PEF. So results of our study may suggest that the CRT can improve some pulmonary function factors of healthy young inactive women beside of other benefits of this type of training for women.

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اثر هشت هفته تمرین مقاومتی دایره‌ای بر عملکرد ریوی زنان غیرفعال

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چکیده

اثر تمرین استقامتی بر دستگاه تنفسی تا حدودی اثبات شده است، اما شواهد اندک و متناقضی در رابطه با تمرین مقاومتی (RT) وجود دارد، بنابراین هدف از تحقیق حاضر، مطالعه اثر هشت هفته RT به شیوه دایره‌ای (CRT) بر عملکرد ریوی زنان غیرفعال بود. نوزده زن داوطلب غیرفعال سالم به طور تصادفی به دو گروه کنترل بدون تمرین (C) و CRT تقسیم شدند. آزمایش اسپیرومتری ۲۴ ساعت قبل و پس از دوره تمرینی انجام شد. دوره تمرین (۸ هفته، ۳ جلسه در هفته) برای CRT شامل ۲ دور در هر جلسه، ۴۰ تا ۶۰ ثانیه برای هر حرکت با ۶۰ الی ۸۰٪ یک تکرار بیشینه بود، و بین هر حرکت و و هر دور به ترتیب ۱ و ۳ دقیقه استراحت فعال در نظر گرفته شد. آزمون ANCOVA نشان داد که CRT بطور معناداری ($p < ۰/۰۵$) سبب افزایش تهویه ارادی بیشینه (MVV)، اوج جریان بازدمی (PEF)، جریان بازدمی اجباری ۷۵٪ - ۲۵٪ (FEF 25%-75%)، و حجم بازدمی اجباری در یک ثانیه (FEV1) شد؛ اما، ظرفیت حیاتی (VC)، ظرفیت حیاتی اجباری (FVC)، و FEV1/FVC تغییر معناداری نکردند. یافته‌ها حاکی از آن است که احتمالاً CRT توانسته در کنار دیگر فواید این نوع از تمرین برای زنان، عوامل عملکرد ریوی زنان جوان غیرفعال را بهبود بخشد.

واژگان کلیدی: تمرین مقاومتی دایره‌ای، VC، FVC، MVV، PEF، FEV1، FEF 25%-75%.

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