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Single and Concurrent Effects of Endurance and Resistance Training on Pulmonary Function

Maryam Khosravi[1], Seyed Morteza Tayebi[1], Hamed Safari[2]

[1] Exercise Physiology Division, Faculty of Physical Education and Sport Science, Islamic Azad University-Ayatollah Amoli Branch, Amol, Mazandaran, Iran

[2] Faculty of Physical Education and Sport Science, Science and Research Branch, Islamic Azad University, Hamedan, Iran

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ABSTRACT

Objective(s): As not only few evidences but also contradictory results exist with regard to the effects of resistance training (RT) and resistance plus endurance training (ERT) on respiratory system, so the purpose of this research was therefore to study single and concurrent effects of endurance and resistance training on pulmonary function.

Materials and Methods: Thirty seven volunteer healthy inactive women were randomly divided into 4 groups: without training as control (C), Endurance Training (ET), RT, and ERT. A spirometry test was taken 24 hrs before and after the training course. The training period (8 weeks, 3 sessions/week) for ET was 20-26 min/session running with 60-80% maximum heart rate (HR max); for RT two circuits/session, 40-60s for each exercise with 60-80% one repetition maximum (1RM), and 1 and 3 minutes active rest between exercises and circuits respectively; and for ERT was in agreement with either ET or RT protocols, but the times of running and circuits were half of ET and RT.

Results: ANCOVA showed that ET and ERT increased significantly ($P< 0.05$) vital capacity (VC), forced vital capacity (FVC), and forced expiratory flows to 25%-75%; ET, RT and ERT increased significantly ($P< 0.05$) maximum voluntary ventilation (MVV); and only ET increased significantly ($P<0.05$) peak expiratory flows (PEF); but ET, RT and ERT had no significant effect ($P>0.05$) on forced expiratory volume in one second (FEV1) and FEV1/FVC ratio.

Conclusion: In conclusion, ET combined with RT (ERT) has greater effect on VC, FVC, FEF rating at25%-75%, and also on PEF except MVV, rather than RT, and just ET has greater effect rather than ERT.

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Introduction

Efficacy of respiratory and pulmonary functions has a direct relationship with general health (1). Furthermore, regular physical activity is of much importance for general health of people, especially young people (2, 3). Since cardiorespiratory endurance is a key component of physical fitness and physical activity can lead to physical fitness, so it can improve cardiorespiratory endurance (4). It is well-documented that the most effective factor in cardiorespiratory fitness is physical activity level (5-7). Exercise training improves endurance and strength of athletes' respiratory muscles; it also causes resistance reduction in respiratory canals, and increases lung elasticity and alveolar expansion as studies have supported the expansion of pulmonary volumes and capacities (8). Accordingly, selection of appropriate type of exercise training may be an important factor in prevention or decrease of respiratory diseases and increase the efficacy of this system.

* *Corresponding author:* Seyed Morteza Tayebi, Exercise Physiology Division, Faculty of Physical Education and Sport Sciences, Islamic Azad University-Ayatollah Amoli Branch, University sideway, Amol to Babol girdle, Amol, Mazandaran, Iran. Tel: +98-121-2122719; Fax: +98-121-2122719; *E-mail:* tayebism@gmail.com

It has been proved that the inability to maintain ventilation with high levels is a factor for restricting maximal aerobic capacity in healthy people (9-11). Although some evidences have reported that the pulmonary system is un- affected by physical activity (12, 13), Crosbie, (2012) after a systematic review of randomized control trials (16 studies and 516 subjects met inclusion criteria), suggested that physical training increases aerobic capacity measured by VO_{2max}, and didn't enhance pulmonary function in children with asthma (14); but it is mainly recommended in various researches that endurance training (ET) is appropriate for improvement of pulmonary function (15); and others found that body endurance is increased by respiratory trainings (16). On the other hand, the effects of RT on inspiratory and expiratory muscles has been investigated and it was concluded that they have positive impacts, both on healthy people and individuals with chronic obstructive pulmonary disease (15, 17, 18). But recently parallel effects of ET and resistance training (RT) have been considered since the studies show further beneficial effects of strength training on improvement of ET function (19). There are some evidences related to RT (15) and parallel training effects on pulmonary function; these studies were done on patients with chronic obstructive pulmonary disease and showed a positive impact on pulmonary function indices (20, 21), but little study has been done on healthy individuals regarding the effect of inspiratory (IMT) (18, 22) and concurrent respiratory muscle training (CRMT) (17) [which are approximately equal to training regimens used in systemic exercise (22)] on pulmonary function and contradictory results have been reported different studies.

Besides, it is known that Iranian women have poor situations for active life style because of their religious beliefs. They might be at risk even if they are healthy. Considering the little evidence about the effect of RT and also endurance plus resistance training (ERT) (23) except healthy subjects specially healthy inactive women, as well as contradictory results of these reports, we aimed to investigate the parallel effects of ET and RT on pulmonary function of healthy inactive women. Therefore we selected four groups with three types of training and tried to keep the intensity and duration of these three types of training the same.

Materials and Methods

Subjects

The study was approved by the research ethics committee of the School of Medical Sciences of Islamic Azad University (Iran), and conducted in accordance with policy statement of the Declaration of Iranian Ministry of Health. Written informed consent was obtained from young inactive healthy women (20-35 years old) who registered in "Hirboud Sport Club" at recent summer (n = 85). 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, and were 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, or myocardial infarction. Then, the acceptable volunteers (n = 36) were classified randomly into 4 groups as follows: a control group (n=9) without training (C), ET group (n=9), RT group (n=10), and ERT group (n=9).

Research design

Participants were taken to the practice hall two times before the beginning of training period. In the first session, their one repeat maximum (1RM) was determined for each of 8 exercises (bench press, curl up, arm extension, leg press, knee flexion, knee extension, plantar flexion, and sit up). In the second 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. Also, HR_{max} was calculated (HR_{max} = 220 - age) for each one and controlled with heartbeat determinant girdle (Phase, Germany) during training. The training sessions started 24 hrs after the spirometry test lasting for 8 weeks, that is three days a week (Saturday, Monday, and Wednesday).

Exercise training procedures

The subjects were instructed to follow a normal lifestyle, to maintain daily habits, and to avoid any regular medications. Each session contained 10 min-warm up and cool down. ET runs for 20 min/sessions with 60-65% HR_{max} in the first 4 weeks and 26 min/session with 65-80% HR_{max} in the second 4 weeks. RT training included two circuits/sessions, 60s (about 12 repeats) for each exercise with 60-65% 1RM, and 1 and 3 minutes specified to 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. ERT exercises were in agreement with either ET or RT protocols, but the times of running and circuits was half of ET and RT, respectively (Table 1).

Statistics

We used ANCOVA to determine the effects of the mentioned three types of training at significance levels of *P*= 0.05. Important ANCOVA assumptions, including linear relationship of dependent variable and covariate, normal distribution, and equality of error variances were examined by Pearson's correlation test, one-sample

Table 1. Summary of Exercise Training Procedures

Types of Training	four weeks	Intensity	Volume	Each exercise for ET	Rest for RT
ET	1st	60-65% HRmax	20min/session		
	2nd	65-80% HRmax	26min/session		
RT	1st	60-65% 1RM	2circuits/session	60s(12repeats)	1 min between exercises and 3min between circuits
	2nd	65-80% 1RM	4circuits/session	40s(8repeats)	
ERT	1st	60-65% HR_{max} plus 60-65% 1RM	10min/session plus 1circuits/session	60s(12repeats)	
	2nd	65-80% HR_{max} plus 65-80% 1RM	13min/session plus 2circuits/session	40s(8repeats)	

ET: Endurance Training; RT: Resistance Training; ERT: Endurance plus Resistance Training

Kolmogorov-Smirnov test, and Levene test, respectively. In variables that assumptions of normal distribution and equality of error variances were not met, we first subtracted dependent variables (post-test) by covariates (pre-test) as new dependent variables. Thus the effects of covariates were removed; then we used Kruskal-Wallis test for k-independent samples, and Mann-Whitney test for paired comparisons as post-hoc test. Significance levels in these paired comparisons was P= 0.0083 (Bonferroni adjustment for multiple comparisons).

Results

General data of subjects including age, and body mass index (BMI) are summarized in Table 2.

Assumptions of linear relationships and normal distribution were met in all variables; however, the one assuming equality of error variances was met only in VC (F = 1.98, P= 0.13), FVC (F = 2.69, P= 0.061), MVV (F = 0.69, P= 0.56), and PEF (F = 1.49, P= 0.235), but not in FEF 25%-75% (F = 5.93, P= 0.002), FEV1 (F = 3.31, P= 0.031), and FEV1/ FVC (F = 3.31, P= 0.031).

Table 2. Descriptive statistics of subjects in four training groups (Mean ± SE)

Factors Types of Training	Age *(Year)*	BMI *(kg/m²)*
Endurance	28.55 ± 1.59	23.29 ± 0.94
Resistance	26.4 ± 1.22	22.26 ± 0.88
Endurance plus Resistance	27.44 ± 1.37	21.55 ± 0.47
Control	26.55 ± 0.94	24.44 ± 1.02

In ANCOVA results, the adjusted mean of dependent variables (post-test in this study) are presented by omission of covariate (pre-test in this study) effects.

VC. The main effect of “Group” on VC was significant (F = 5.201, P= 0.005). With respect to adjusted mean, ET and also ERT were significantly greater than RT and C. Other comparisons were not significant (Figure 1). It showed a 14.9%, 2.4%, 14.4%, and 3.4% elevation in ET, RT, ERT, and C, respectively. In other words, ET and ERT caused significant improvement in VC, but RT had no significant effect.

FVC. The main effect of “Group” on FVC was also significant (F = 9.235, P= 0.000). ET was significantly greater than RT and C, and ERT was greater than C. Other comparisons were insignificant (Figure 2). It showed a 23.1%, 6.55%, 19.1%, and 3.2% increase in ET, RT, ERT, and C.

MVV. The main effect of “Group” on MVV was also significant (F = 9.235, P= 0.000). ET, RT and their combination (ERT) were significantly greater than C; but other comparisons were not significant (Figure 3). It showed a 3.9%, 2.61%, and 2.45% elevation in ET, RT, and ERT, respectively, and a 0.05% depression in C.

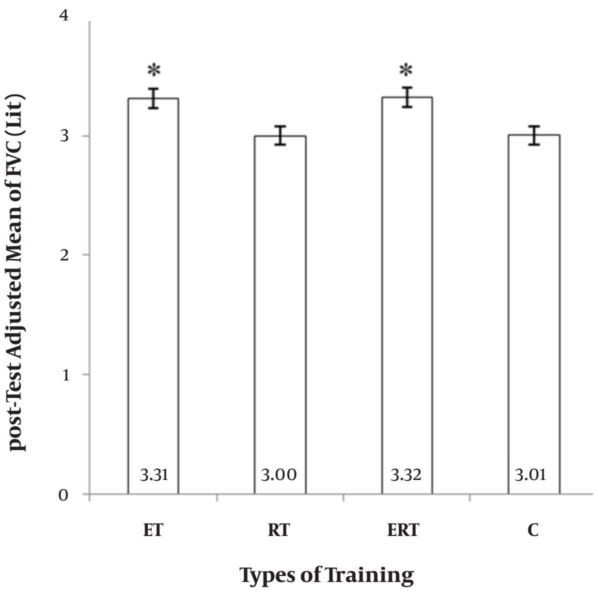

Figure 1. *Between-group differences for Vital Capacity (VC).* ET: endurance training. RT: resistance training. ERT: endurance plus resistance training. C: control without training. *: significantly greater than Resistance and Control group (P≤ 0.05).

PEF. The main effect of “Group” on PEF was also significant (F = 4.966, P= 0.006). ET was significantly greater than C, but other comparisons were not significant (Figure 4). It showed a 8.5%, 5.7%, 4.0%, and 2.04% elevation in ET, RT, ERT