Aerobic Exercise Training Improves Cardiopulmonary Fitness among Firefighters

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ABSTRACT

***Aim**: Firefighters experience short bursts of extreme physical and psychological stress punctuating long periods of tedium. For short intervals, the physical demands of firefighting may approach the limits of human capacity, so there is a need to find the most appropriate type of exercise training that achieve the best cardiopulmonary fitness in firefighters that enables them to do their work. The purpose of this study was to determine changes in cardiopulmonary fitness after aerobic and anaerobic exercise training in firefighters.*

***Method**: Forty firefighter workers who practiced their job for no less than fifteen years were enrolled in this study, their age ranged from 32 to 41 years. Participants were included into 2 equal groups; group (A) received aerobic treadmill walking exercise training for 3 months, at a frequency of 4 sessions per week. The second group (B) received anaerobic exercise training for 3 months, at a frequency of 2 sessions per week. Measurements of systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), minute ventilation (VE) and Maximum oxygen consumption (VO_2max) obtained for both groups before and after the exercise program.*

***Result**: The mean SBP, DBP and HR values were significantly decreased, where the mean VE and VO_2max values were significantly increased in group (A) after training. The mean SBP, DBP and HR values were not significant statistically and the mean VE and VO_2max values were significantly increased in group (B) after training. There were significant differences between mean levels of SBP, DBP ,HR and VE in group (A) and group (B) after training, where there was no significant difference between mean levels of VO_2max in group (A) and group (B) after training.*

***Conclusion**: Aerobic exercise training is the most appropriate type of exercise training that achieves the best cardiopulmonary fitness in firefighters that enables them to do their work.*

***Key words**: Cardiopulmonary fitness, aerobic, anaerobic, exercise, firefighters.*

Aerobik Egzersiz İtfaiyeciler Arasında Kardiopulmoner Formda Olmayı Düzeltir

Amaç: İtfaiyeciler, uzun dönemde tekrar eden, aşırı fiziksel ve psikolojik stres ihtiva eden kısa patlama dönemleri yaşarlar. Kısa süreler için itfaiyecilerin fiziksel gereksinimleri insan kapasitesinin sınırlarına yaklaşabilir,bu nedenle itfaiyecilerin işlerini uygun şekilde yapmalarına olanak sağlayacak en iyi kardiyopulmoner formun yakalanabilmesi için en uygun tipte egzersiz idmanının tespit edilmesi bir ihtiyaçtır. Bu çalışmanın amacı itfaiyecilerde aerobik ve anaerobik egzersiz sonrasında kardiyopulmoner formdaki değişiklikleri tespit etmekti.

Metod: En az 15 yıldır mesleklerini icra eden 40 itfaiye işçisi çalışmaya alındı, yaşları 32 ile 41 arasında değişmekteydi. Katılımcılar iki eşit gruba ayrıldılar; grup (A) haftada 4 seans olmak üzere 3 ay boyunca aerobik treadmill yürüme egzersizi aldılar. Grup (B) haftada 2 seans olmak üzere 3 ay boyunca anaerobik egzersiz idmanı yaptılar. Her iki grup için egzersiz programından önce ve sonra olmak üzere sistolik kan basıncı (SKB), diyastolik kan basıncı (DKB), kalp hızı (KH), dakika ventilasyonu (DV) ve maksimum enerji tüketimi için (VO_2max) ölçümler yapıldı.

Bulgular: Tİdman sonrası grup (A) da ortalama SKB, DKB ve KH anlamlı derecede azalırken, ortalama DV ve VO2max anlamlı derecede artış gösterdi. Grup (B)'de idman sonrası ortalama SKB, DKB ve KH istatistiksel olarak anlamlı değilken, ortalama DV ve VO_2max anlamlı derecede artış gösterdi. İdman sonrasında grup (A) ve grup (B) arasında ortalama SKB, DKB, KH ve DV açısından anlamlı farklılıklar tespit edilirken VO2max açısından gruplar arasında anlamlı bir farklılığa rastlanmadı.

Sonuç: Aerobik egzersiz idmanı itfaiyecilerin mesleklerini icra etmelerine imkan sağlayacak en iyi kardiyopulmoner formdalığı sağlayacak en uygun egzersiz programıdır.

Anahtar kelimeler: Kardiyopulmoner formda olma, aerobik, anaerobik, egzersiz, itfaiyeci.

INTRODUCTION

Firefighting is an occupation inherent with environmental dangers (heat, chemical exposure, structural failures, etc), mental stress, and physical exertion (1). Multiple studies have shown that firefighters have increased rates of ischemic heart disease compared to other population (2-4). A retrospective examination of firefighter deaths resulting from coronary heart disease found that fire suppression activities resulted in the greatest risk of death to firefighters (12.1–136 times as high) when compared to non-emergency duties (5). Explanations for this augmented mortality risk are limited, although stress has been specifically implicated as a possible contributing factor for the elevated risk of coronary heart disease (6,7).

Cardiovascular disease is the leading cause of death among firefighters (8). Coronary heart disease (CHD) accounts for 39% of "on-duty" deaths in firefighters in the United States. Current smoking and hypertension are strong predictors of fatality in male firefighters experiencing on-duty CHD events. Accordingly, prevention efforts should include early detection and control of hypertension, smoking cessation/prohibition, and the restriction of most firefighters with significant CHD from strenuous duties (9).

Regular aerobic training induces significant adaptations both at rest and during exercise in a variety of dimensional and functional capacities related to the cardiovascular and respiratory regulation system (10). However, High-intensity exercise (anaerobic) training has the added benefit of improving fitness, thus making low-intensity exercise less difficult and more easily tolerated. Although continuous intense exercise is difficult to maintain for extended periods of time (11).

Firefighters experience short bursts of extreme physical and psychological stress punctuating long periods of tedium. For short intervals, the physical demands of firefighting may approach the limits of human capacity (12). As there is a need to find the most appropriate type of exercise training that achieves the best cardiopulmonary fitness in firefighters that enables them to do their work. Therefore, the purpose of this study was to determine changes in cardiopulmonary fitness after aerobic and anaerobic exercise training in firefighters

MATERIALS AND METHODS

Subjects

Forty firefighter workers (mean age 31.27±8.14 years) who practiced their job for no less than fifteen years were enrolled in this study. Participants were included into 2 equal groups; group (A) received aerobic treadmill walking exercise training for 3 months, at a frequency of 4 sessions per week. The second group (B) received anaerobic exercise training for 3 months, at a frequency of 2 sessions per week. All participants were free to withdraw from the study at any time. If any adverse effects had occurred, the experiment would have been stopped, with this being announced to the Human

Table 1. Mean standard deviation and significance of VO_2max, VE, HR, SBP and DBP in aerobic and anaerobic exercise group before training.

	Aerobic	Anaerobic	T-value	Significance
VO_2 max (L/min/Kg)	3.06±0.16	3. 05±0.134	0.284	ns
VE (L/min)	105.14±10.6	106.01±7.76	0.563	ns
HR (Beat/min)	82.14±2.78	81.68±3.61	0.518	ns
SBP (mmHg)	136.1±5.97	136.15±4.87	0.224	ns
DBP (mmHg)	87.4±4.48	88.12±4.30	0.386	ns

VO2max = Maximum Oxygen Consumption, VE = Minute Ventilation, HR = Heart Rate, SBP = Systolic Blood Pressure, DBP = Diastolic blood pressure, ns: non significance

Subjects Review Board. However, no adverse effects occurred, and so the data of all the participants were available for analysis. All participants provided written informed consent, and the University of King Abdulaziz institutional ethical review board approved the study.

Methods

Equipment

Cardiopulmonary exercise test unit (CPET): (Zan 800; made in Germany). It consists of breath gas (O_2 and CO_2) analyzer, electronic treadmill, 12 channels electrocardiogram, (ECG) monitor, gas bottle and mask with a diaphragm to analyze gas. The speed and the inclination of treadmill were be controlled by pre-selected soft ware (Bruce standard protocol) .The final test results were print out by the printer. This unit was calibrated daily. Its speed and inclination and timer are adjustable, and it also provided with control panel to display the exercise parameters. Pulsometer (Tunturt TPM-400, made in Japan) it was used to detect heart rate before, during and after exercise. Spirometer (Schiller-Spirovit Sp-10, Swizerland) was used to minute ventilation (VE). Mercury sphygmomanometer (Diplomat, Presameter made in Germany) and stethoscope (Riester, duplex, made in Germany); it was used to measure blood pressure before, and after exercise training sessions.

Evaluation procedures

Before starting the study, a consent form was taken from each participant as an agreement to be included in the present study also before initiation of exercise training program each subject was examined medically by a physician in order to exclude any abnormal medical problems which previously mentioned. A brief description had been given about the tasks expected during the test.

Cardiopulmonary exercise test procedure

Before conducting the exercise tolerance test, all subjects had to visit the laboratory to be familiarized with the equipment in order to be cooperative during conducting the test. Each subject underwent continuous progressive exercise tolerance test according to Bruce standard protocol which consists of warming up phase and five active phases and recovery phase in order to determine the maximum oxygen consumption (VO2max). Systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), minute ventilation (VE) and Maximum oxygen consumption (VO_2max) obtained for both groups before and after the exercise program.

Table 2. Mean standard deviation and significance of VO_2max, VE, HR, SBP and DBP in aerobic exercise group before and after training.

	Before	After	T-value	Significance
VO_2 max (L/min/Kg)	3.067±0.163	3.498±0.156	10.051	$p<0.05$
VE (L/min)	105.14±10.64	132.42±12.53	11.267	$p<0.05$
HR (Beat/min)	82.14±2.78	73.25±3.76	7.875	$p<0.05$
SBP (mmHg)	136.11±5.97	124.71±6.67	5.183	$p<0.05$
DBP(mmHg)	87.4±4.48	83.21±5.089	8.761	$p<0.05$

Table 3. Mean standard deviation and significance of VO2max, VE, HR, SBP and DBP in anaerobic exercise group before and after training.

	Before	After	T-value	Significance
VO2 max (L/min/Kg)	3. 05±0.13	3.38±0.15	6.172	p<0.05
VE (L/min)	106.01±7.76	129.76±10.7	7.166	p<0.05
HR (Beat/min)	81.68±3.6	82.1±4.87	0.482	ns
SBP (mmHg)	136.15±4.87	137.2±5.87	0.341	ns
DBP(mmHg)	88.12±4.3	88.97±3.7	1.104	ns

The aerobic exercise training program

The aerobic treadmill-based training program (Zan 800; made in Germany) was started with a 5-minute warm-up phase performed on the treadmill at a low load, Active phase of the training session was gradually increased from 20 to 40 minutes in the form of walking/running on electronic treadmill with zero inclination four times per weak for twelve weeks, its intensity gradually from 60% to 80% of the maximum heart rate (HRmax) achieved in a reference ST performed according to a modified Bruce protocol. This rate was defined as the training heart rate (THR) and ended with 5-minute recovery and relaxation phase. All patients performed four weekly sessions (i.e. a total of 48 sessions per patient over a 3-month period) (13).

The anaerobic exercise training program

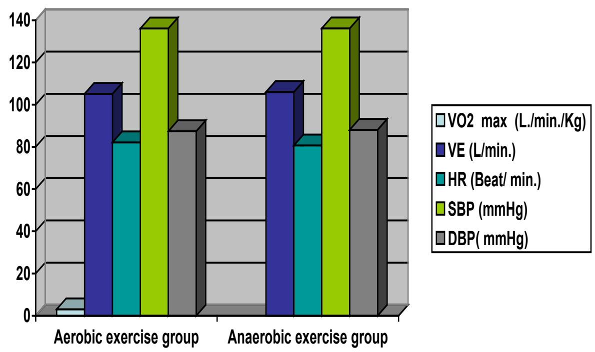
The anaerobic treadmill-based training program was started with a 5-minute warm-up phase performed on the treadmill at a low load, Active phase of the training session was Started firstly with 2 minutes gradually increased 5 second each session until reach 3 minutes then rest for 2 minute this bout was repeated 5 times each session in the form of running on electronic treadmill gradually from 85% to 93% of HRmax achieved in a reference ST performed according to a modified Bruce protocol. This rate was defined as THR and ended with 5-minute recovery and relaxation phase. All patients performed two weekly sessions (i.e. a total of 24 sessions per patient over a 3-month period) (14).

Statistical analysis

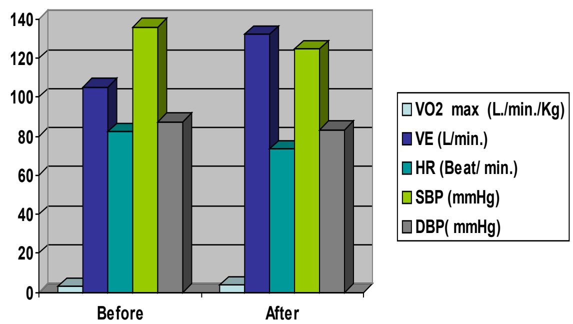
The mean values of SBP, DBP, HR, VE and VO_2max obtained for both groups before and after the exercise program were compared using paired "t" test. Independent "t" test was used for the comparison between the two groups (p<0.05).

RESULTS

Forty firefighter workers who practiced their job for no less than fifteen years were enrolled in this study, their



***Figures 1**. Mean standard deviation and significance of VO_2max, VE, HR, SBP and DBP in aerobic exercise group and anaerobic exercise group before training.*



***Figures 2**. Mean standard deviation and significance of VO_2max, VE, HR, SBP and DBP in aerobic exercise group before and after training.*

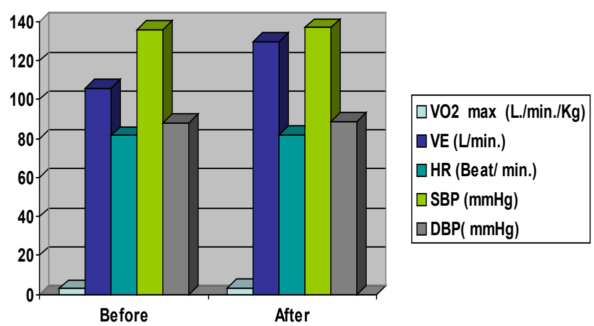
Table 4. Mean standard deviation and significance of VO2max, VE, HR, SBP and DBP in aerobic exercise group and anaerobic exercise group after training.

	Aerobic	Anaerobic	T-value	Significance
VO_2 max (L/min/Kg)	3.49±0.15	3.38±0.15	0.136	ns
VE (L/min)	132.4±12.5	129.76±10.7	6.183	p<0.05
HR (Beat/min)	73.25±3.76	82.1±4.87	3.871	p<0.05
SBP (mmHg)	124.7±6.67	137.2±5.87	6.630	p<0.05
DBP(mmHg)	83.2±5.08	88.97±3.7	4.827	p<0.05

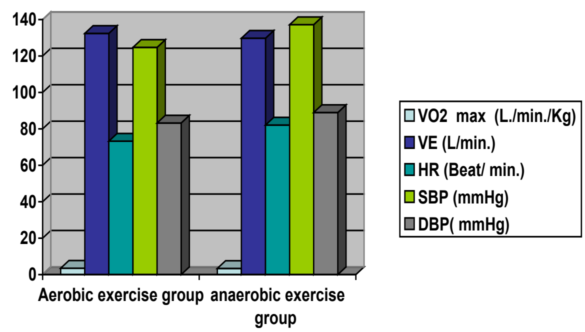
age ranged from 32 to 41 years. Participants were included into 2 equal groups; group (A) received aerobic treadmill walking exercise training. The second group (B) received anaerobic exercise training. There was no significant differences between the mean SBP, DBP, HR, VE and VO_2max values of both groups before training (Table1, Figure 1) .The mean SBP, DBP and HR values were significantly lower statistically , where the mean VE and VO_2max values were significantly higher statistically in group (A) after training (Table 2, Figure 2). The mean SBP, DBP and HR values were not significant statistically and the mean VE and VO_2max values were significantly higher in group (B) after training (Table 3, Figure 3). There were significant differences between mean levels of SBP, DBP ,HR and VE in group (A) and group (B) after treatment ,where there was no significant difference between mean levels of VO_2max in group (A) and group (B) after training (Table 4, Figure 4).

DISCUSSION

The results also indicated that there was a significant increase in VO_2max values after aerobic and anaerobic exercise program. However, there was no significant difference between the two groups after training . Carsten et al. agreed with this result as they explain the significant increase in VO_2max is related to the effect of exercise either aerobic or anaerobic improve the respiratory function as vital capacity, inspiratory reserve volume and expiratory reserve volume of the lungs, also the stroke volume of the heart increase by regular exercise. These respiratory adaptations facilitate oxygen supply to tissues and add further evidence to the improvement of the respiratory fitness (15). Also Tomohiro et al. confirmed this results as he reported that moderate intensity exercise have a significant increase in VO2max as well as participating in bouts of high intensity anaerobic exercise (16). However, Audrey et al. reported that brief but intense sprint interval training can result in an increase in both glycolytic and oxidative muscle enzyme activity, maximum short-term power output,



Figures 3. Mean standard deviation and significance of VO_2max, VE, HR, SBP and DBP in anaerobic exercise group before and after training.



Figures 4. Mean standard deviation and significance of VO_2max, VE, HR, SBP and DBP in aerobic exercise group and anaerobic exercise group after training.

and VO_2max (17).

The results also indicated that there was a significant increase in VE values after aerobic and anaerobic exercise program. Also there was a significant difference between the two groups after training. These results supported by Michael et al. reported that ventilation and gas exchange during maximal incremental exercise were increased after sprint training (18). Also, Chacon et al. reported that aerobic training induces significant physiological adaptations in the cardio-respiratory system of middle-aged men. The best markers of these adaptations were the smaller sympathetic tachycardia at comparable workloads and the improvement of oxygen transport, as documented by the increase in the anaerobic threshold and VO_2max (19).

The results also indicated that there was a significant reduction in heart rate, systolic and diastolic blood pressure after aerobic exercise training in group (A). These results supported by Skinner et al. reported that regular aerobic training induces significant adaptations both at resting and during maximum exercise in a variety of dimensional and functional capacities related to the cardiovascular and respiratory regulation system, enhancing the delivery of oxygen into active muscles these changes include decreases in heart rate, enhanced stroke volume and cardiac output (11). Also, Joyner and Tschakovsky explained the reduction of heart rate, systolic and diastolic blood pressure after aerobic training to be due to Nitric oxide that seems to be an important and potent endothelium-derived relaxing factor that facilitates blood vessel dilatation and decreases vascular resistance (20)

Hepple reported that peripheral vascular adaptation, which includes enhanced perfusion and flow capacity, has been observed after regular aerobic training. Total leg blood flow during strenuous exercise increases in parallel with a rise in maximal aerobic power. In addition, the arteriovenous oxygen difference in muscle increases after aerobic training. These adaptations may arise from structural modifications of the vasculature and alterations in the control of vascular tone. An increase in the capillary density of muscle has also been shown after training. Both capillary density and blood flow increase in proportion to the rise in maximal aerobic power during long-term aerobic training interventions which may have a strong role in decreasing the heart rate and blood pressure (21).

The results also indicated that there are no significant changes in heart rate, systolic and diastolic blood pressure after anaerobic exercise training in group (B). This reflects an increased cardio respiratory load related to the prolonged duration of training session from 20 to 30 minutes. However, the greater blood flow under the influence of the rise in heart rate and systolic blood pressure did not satisfy the increased oxygen requirements during anaerobic exercise. This explains the significant augmentation of pulmonary ventilation and ventilation capacity in a trial to satisfy the expanding oxygen transport requirements during maximal exercise. Deschenes and Kraemer agreed with the results of our study as they reported that participation in heavy resistance anaerobic training over extended period of time increase cardiac work and thus it couldn't be sustained over extended period of time (22).

In conclusion, aerobic exercise improves cardiopulmonary fitness in firefighters while anaerobic exercise increases cardiac work and it is difficult to be maintained for extended periods of time. Moreover, aerobic exercise is less difficult; more easily tolerated and can be practiced daily over an extended period of time. So, aerobic exercise training is the most appropriate type of exercise training that achieves the best cardiopulmonary fitness in firefighters that enables them to do their work.

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