Efficacy of Moderate Exercise Training on Cardiopulmonary Fitness among Elderly Women

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ABSTRACT

***Purpose**: The purpose of this study was to investigate the effect of aerobic training on cardiorespiratory fitness among elderly female. **Subject**: Forty female elderly subjects had participated in this study, their age ranged from 65 to 75 years old with a mean value of 67.1±3.7 years. They were selected randomly from different geriatrics nursing homes in Cairo based on the inclusion criteria and were totally supervised clinically by internal medicine and geriatric specialist. **Methods:** All the subjects had participated in moderate aerobic training calculated as 65% to 75% of their pre determined maximum heart rate. This program was applied three times per week for two months.Cardiopulmonary exercise test was conducted for all subjects before and after the training program to determine the cardiorespiratory fitness related indices, and their hemodynamic response to exercise. **Results**: The results of this study revealed a significant improvement in most of the cardiorespiratory fitness indices as significant increase in the maximum oxygen consumption (VO_2max) , and significant increase of the forced vital capacity. This in addition to the significant increase of the maximum heart rate, decrease of the resting heart rate, resting and maximum systolic blood pressure, associated with non significant improvement of the resting and maximum diastolic blood pressure.*
***Key words:** Aging, Aerobic training, Cardio respiratory fitness.*

INTODUCTION

In Egypt the aged population in the 1976 consensus reached 2.3 millions and increased to reach 2.95 million in the 1986 consensus and 3.027 in the 1996 consensus. It is interesting to notice that the percentage increase in the total population of Egypt between years 1986 to year 2006 is nearly 47%. However, the rate of increase of the older sector of the population occurs in a much faster rate as the percentage increase of older people above the age of 60 (during the same period) is about 72%[27].

"Aging is accompanied by a decline in functional reserve as reflected by a gradual decrease in the maximum oxygen consumption (VO_2max). In fact, the functional capacity of the cardiovascular system of adults over the age of 70 years is less than half that of young individuals, with some older individuals exhibiting VO_2max values lower than that required to perform many activities of daily living"[21,22]. "The etiology of the decline is multifactorial and attributable to decreases in muscle mass and function, sedentary lifestyle, weight gain, and the development of both subclinical and overt cardiovascular and musculoskeletal diseases"[21,34].

"It is well recognized that the functional capacity of the cardiovascular system as assessed by maximal aerobic capacity or VO_2max declines with advancing age. This decrease contributes to an increased risk of developing physiologic and metabolic abnormalities, which eventually can result in a loss of independence, increased incidence of disability and disease, and reduced quality of life in older adults. Moreover, because a low VO_2max is an independent risk factor for cardiovascular and all-cause mortality, its decrease with age also contributes to premature death in middle-aged and older adults. Although chronic exercise does not prevent the age-related decrease in VO_2max, it is evident that active and athletic individuals possess significantly greater aerobic capacity and reduced risk for cardiovascular and other associated diseases than sedentary individuals of similar age"[21].

The maximal oxygen intake declines by about 5 ml.kg-1.min-1 per decade from 25 to 65 years of age, with some possible acceleration thereafter. It is difficult to be certain how much of this loss is inevitable, and the extent to which the decline results from a progressive decrease of habitual physical[8,14]. Maximal oxygen consumption (VO_{2max}) became the primary measure of exercise capacity and cardiopulmonary fitness and the mechanisms related to delivery of oxygen to the muscles were considered the main factors determining exercise capacity. The maximal capacity of an individual to perform aerobic work is defined by the (VO_{2max}); the product of cardiac output and arteriovenous difference at exhaustion. Although VO_{2max} is measured in liters per minute, it is usually expressed per kilogram of body weight to facilitate intersubject comparison[17].

Maximal heart rate decreases mainly because of a decreased responsiveness to circulating catecholamine. The classical equation [peak rate = (220 - age in years)] implies a maximum of about 155 beats. The diastolic blood pressure increases until the age of about 60 years and then stabilizes or even falls, whereas the systolic blood pressures significantly increase from 20 to 80 years. Specifically the systolic blood pressure tends to increase with age throughout life, which is the main cause of isolated systolic hypertension in the elderly. The systolic pressure increases with age due to a decreased of the arterial compliance[12].

There is a progressive decrease in the vital capacity due to increased stiffness of the chest wall, loss of elastic recoil of the lung, and decreased force generated by the respiratory muscles. There is an increase in the residual volume such as the total lung capacity (TLC) remains fairly constant due to the same mechanisms. The functional residual capacity (FRC) also increases with age, although to a lesser degree because this increase is counteracted slightly by a stiffening of the chest wall[6,20].

"In addition to presenting challenges to maintaining physical independence and quality of life with aging, low cardiorespiratory fitness is also an independent predictor of cardiovascular disease and all-cause mortality. During a 6-year follow-up period, peak exercise capacity was the best predictor of risk of death among older men with and without cardiovascular disease referred for treadmill exercise testing. The risk of death from cardiovascular events among those with an exercise capacity of less than 5 metabolic equivalents (METs) was nearly double that of those with an exercise capacity above 8 METs. Moreover, every 1 MET increase in exercise capacity was associated with a 12% improvement in survival rate"[21].

The American College of Sports Medicine recommends cardiopulmonary exercise testing for all sedentary or minimally active older adults who plan to begin exercising at a vigorous intensity.[35] Cardiopulmonary exercise testing with ventilatory gas analysis provides information on cardiac performance, functional limitation and exercise limitations particularly when the symptom limiting the individual is breathlessness or Dyspnea and it is performed by progressive increasing work rate to help in determining the level of the subjects exercise limitation[25].

Age related changes in cardiopulmonary system reduce the physical work capacity that may negatively reflect on their quality of life. Exercise training cannot restore tissue that has already been destroyed, but it can protect the individual against a number of the chronic diseases of old age. more importantly, it maximizes residual function. Exercise is thus a very important component of healthy living[1,10,16,31]. Since few literatures has been done to study the direct effect of regular aerobic exercise on cardiopulmonary fitness parameters in elderly, this piece of work would be very beneficial to investigate the direct effect of regular training on physical fitness indices among female elderly that will assist also to understand the best way to rehabilitate those subjects in a way that improve their quality of life.

SUBJECTS, MATERIAL AND METHODS

Subjects

Forty elderly female subjects were involved in this study. Their age ranged from 65 to 75 years old with a mean value of 67.1$\pm$3.7 years. Their weights ranged from 56 to 70 Kg with a mean value 65.9 $\pm$ 3.96 Kg, their height ranged from 144 to 170 cm with a mean value 157.5 $\pm$ 7.6 cm. They were selected randomly from different geriatrics nursing homes in Cairo based on the inclusion criteria and were totally supervised clinically by internal medicine and geriatric specialist. Subjects who were diagnosed as having ischemic heart disease, rheumatic heart disease, unstable metabolic disorders; sever orthopedic disorders that could be aggravated by exercise, COPD, emphysema, mental or psychological disorders, advanced neuromuscular, neurological, or any other chronic debilitating condition in which exercise would be contraindicated were excluded from participating in this study.

Materials

* **Cardiopulmonary exercise test unit (CPET):** (ZAN; MeBgerate GmbH, Germany) at the laboratory of the faculty of physical therapy. It consists of breath gas (O2 and CO2) analyzer; electronic treadmill (SN RAM; Germany); 12 channels electrocardiogram (ECG) .The breath gasses were measured using breath by breath technique and open circuit method. The work load pattern of treadmill was controlled by preselected soft wear. Built in self-adhesive electrocardiogram (ECG) electrodes were used to pick up ECG signals during the exercise test. The results of the test were displayed on one panel for O_2, CO_2 analysis curves, and to display ECG traces. As will the final results of the test were printed out by the thermal printer. This unit was calibrated daily.
* **Height and weight scale:** (Floor type Model ZT-120, made in China) It is used to measure the height and the weight of each subject, to be used as data base for the cardiopulmonary exercise test
* **Mercury sphygmomanometer:** (Diplomat, Presameter made in Germany) and stethoscope (Riester, duplex, made in Germany). It was used to measure the blood pressure before, and after each exercise training session.
* **Pulsometer:** (Tunturt TPM-400, made in Japan) It was used to detect the pulse rate before, during and after exercise, and to control exercise intensity within the

precalculated training heart rate during every exercise session.

* **Electronic Treadmill:** (Enraf Nonius, EN – TRED, made in Germany) at faculty of physical therapy clinic. Its speed, inclination and timer are adjustable, and it also provided with control panel to display the exercise parameters. It was used for the training sessions

Methods

Testing procedure

* All the evaluation and the treatment procedures had been conducted at the cardiopulmonary lab of the faculty of the physical therapy, Cairo University
* The history of each subject was taken carefully to collect information about his general condition, physical activity and current medication.
* The purpose of the training program was explained for each subject.
* Each subject had been clinically evaluated by geriatric specialist to exclude subjects with any of the exclusion criteria.
* Every subject had received general explanation of cardiopulmonary exercise test procedure and brief description had been given about the exercise test environment at least one day before the exercise test, in addition to education regarding the signs and symptoms related to the termination of exercise test. All the participants have signed a written informed consent before the exercise test, and the exercise programs.
* All subjects had performed the cardiopulmonary exercise test on electronical treadmill according to Bruce protocol with built in 12 leads ECG monitoring system.[35] The test is composed of 3 minutes multistages with gradual increase of the speed and inclination of the treadmill. During the first 2 minutes of the test, the patient was standing without walking to allow the system to analyze the ventilation characteristics under resting condition. Patients were encouraged to exercise until symptoms were intolerable. Investigator-determined exercise end points were severe ventricular tachycardia of >5 beats, ST-segment depression >3 mm, systolic blood pressure >250 mm Hg, or progressive decrease in blood pressure.[11] During the test the expired gases were investigated using breath-breath analysis through breathing mask (Oxycon B, Jaegar), to calculate the VO_2 max.[11] The maximal oxygen consumption, , resting and maximum heart rate and resting and maximum systolic and diastolic blood pressure have been selected from the printed results and taken as indices for evaluation cardiopulmonary fitness[33].
* Forced Vital capacity was measured by the Spiro metric part of the cardiopulmonary exercise test unit, it was carried out at affixed time of the day to minimize diurnal variation[17]. The apparatus was calibrated daily and operated within the ambient temperature range of 20-25C.

Training procedure

Each subject had participated in aerobic training program three times per week for two months using treadmill with moderate intensity of aerobic exercise[37]. The exercise intensity has been prescribed as a training heart rate (THR) based on each subject's maximum heart rate (HR max), and resting heart rate (HR rest) obtained from the exercise test, and calculated according to Karvonen formula as follow

THR=HRrest + (HRmax –HRrest) TF

TF=training fraction, it was 65-75% in moderate training[28].

Each subject had started training session by warming up exercise for 5-10 minutes in the form of stretching exercise, marching in place or even walking on the treadmill with heart rate reaching to 30-40% of the HRmax to adjust cardiopulmonary system, minimize formation of lactic acid, and to decrease the risk of hypotension, musculoskeletal and cardiovascular complications[25].Warming up phase had followed by the active phase during which the speed was increased gradually until subject reaches to the range of 65-75% of HRmax for 30 minutes. Then the exercise session was ended by cooling down by gradual reduction of the treadmill speed to allow another 5 minutes of very slow walking before stopping the treadmill to avoid postural hypotension[26]. Pulse rate had been continuously monitored during the session .The subject was instructed to document any significant symptoms felt during the session to the physiotherapist.

Statistical procedures

In this study collected data were fed to the computer, manipulated and analyzed using (SPSS under win; statistical package, version 10, 1998).Descriptive statistical analysis, in the form of mean, standard deviation was calculated for all pre and post training variables. The comparison was made by t-test to determine the probability levels for differences in the mean values between the results observed before and after the training program. Statistical significance was established at the conventional <0.05 level

RESULTS

This study was done to investigate the effect of aerobic training on cardiopulmonary fitness among elderly female. The data gathered before and after 8 weeks of aerobic training were treated statistically and presented the statistical analysis of resting and maximum heart rate, resting systolic and diastolic blood pressure, maximum systolic and diastolic blood pressure, maximum oxygen consumption, and forced vital capacity as indices for the cardiorespiratory fitness.

Table (1): The mean values of the resting heart rate (HRrest and HRmax***) pre and post aerobic training program for the all subjects.***

Variables	Pre-training mean ± SD	Post-training mean ± SD	t-value	P-value
Resting heart rate	90.7 ± 7.6	82.6 ± 7	6.5	< 0.05
Maximum heart rate (HRmax)	104.90 ± 12.5	115.25 ± 9.45	8.851	< 0.05

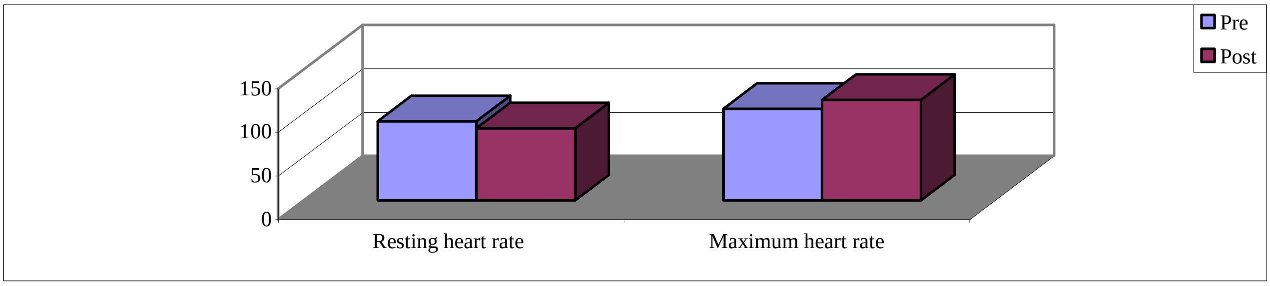

Fig. (1): The mean values of the resting and maximum heart rate pre and post aerobic training program for the study group.

As observed from table (1) and figure (1), the exercise training program had significantly reduced (P-value < 0.05), the resting heart rate (HRrest) from the average value of 90.7±7.6 beat /minute before training to the average value of 82.6±7 beat /minute after training. It had also significantly increased (P-value < 0.05), the maximum heart rate (HRmax) from the average value of 104.90 ± 12.5 beat /minute before training to the average value of 115.25±9.45 beat /minute after training.

Table (2): The mean values of the Blood pressure (BPrest and BPmax) pre and post aerobic training program for the all subjects.

Variables	Pre-training mean ± SD mmHg	Post-training mean ± SD mmHg	t-value	P-value
Resting SBP	135.55 ± 8.1	133 ± 7.75	4.058	< 0.05
Resting DBP	86.60 ± 8.05	86.325 ± 7.84	0.89	> 0.05
Maximal SBP	149.5 ± 8.27	147.775 ± 5.8	2.67	< 0.05
Maximal DBP	93.27 ± 9.1	92.7 ± 8.7	1.7	> 0.05

SBP: systolic blood pressure DBP: diastolic blood pressure SD: Standard Deviation

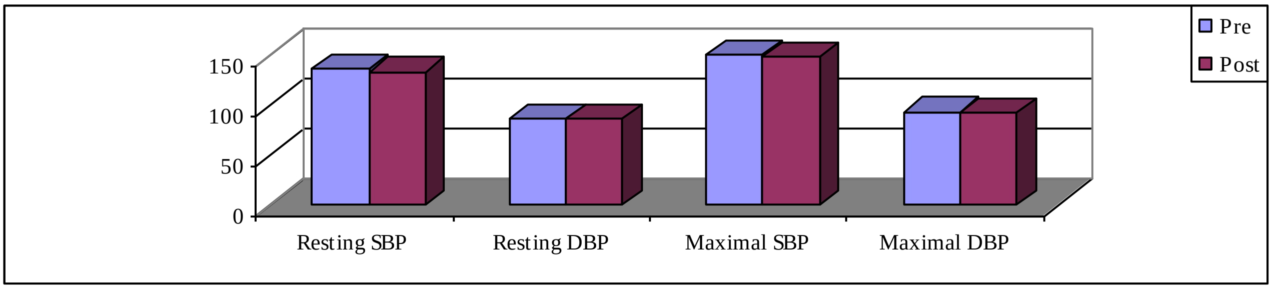

Fig. (2): Thee mean values of blood pressure (BPrest and BPmax) pre and post aerobic training program for the all subjects.

As observed from table (2) and figure (2), the exercise training program had significantly reduced (P-value < 0.05), the resting systolic blood pressure (SBPrest) from the average value of 135.55±8.1 mmHg before training to the average value of 133±7.75 mmHg after training and had also reduced the maximal systolic blood pressure (SBPmax) from the average value of 149.5±8.27 mmHg before training to the average value of 147.775±5.8 mmHg after training. On the other hand moderate exercise training for two months had failed to reduce (P-value > 0.05), the resting diastolic blood pressure (DBPrest) and the maximal diastolic blood pressure (DBPmax) as their average values before training were 86.60±8.05 mmHg and 93.27±9.1 mmHg respectively ,while their average values after training were 86.3±7.84 mmHg and 92.7±8.7mmHg respectively.

Table (3): The mean values of the (VO_2max, AT and FVC) pre and post aerobic training program for the all subjects.

Variables	Pre-training mean ± SD	Post-training mean ± SD	t-value	P-value
VO_2max ml/kg/min	16.8 ± 3.3	23.4 ±4.25	12.6	< 0.05
FVC Liter	2.1 ± 0.67	3.18 ± 1.12	7.11	< 0.05

VO_2 max: Maximal oxygen consumption (FVC): Forced vital capacity SD: Standard Deviation

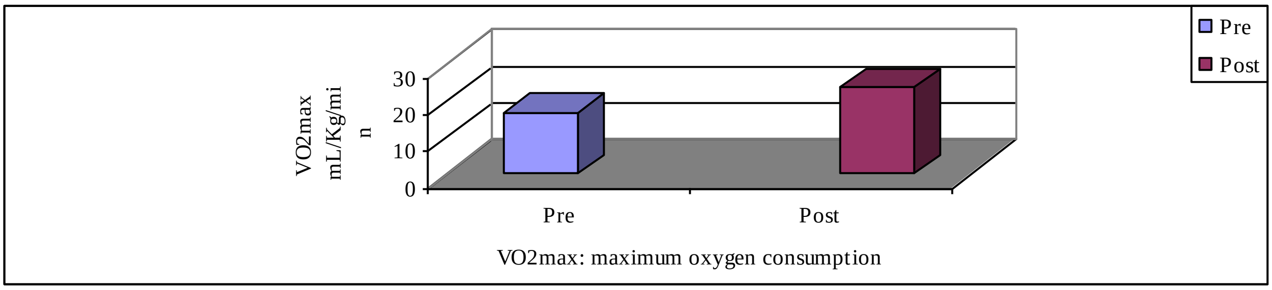

Fig. (3): The mean values of (VO2max) pre and post aerobic training program for the all subjects.

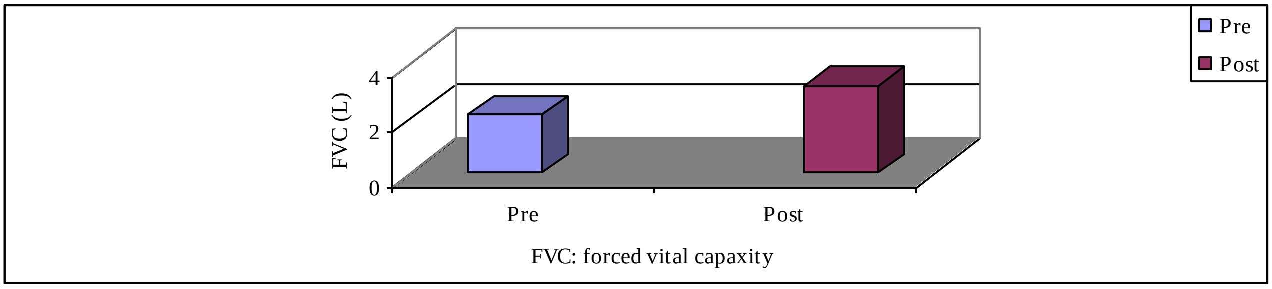

Fig. (4): The mean values of (FVC) pre and post aerobic training program for the all subjects.

As observed from table (3) and fig. (3,4) the exercise training program had significantly increase ($P < 0.05$), the maximal oxygen consumption (VO_2max) and the forced vital capacity (FVC) from the average value of 16.8 mL/kg/min, and 2.08 L before training to the average value of 24.3 mL/kg/min and 3.18 L after training respectively.

DISCUSSION

This study was done to investigate the effect of aerobic training on the cardiorespiratory fitness among elderly female. Forty elderly female subjects were participated in this study. Each subject of this study had participated in aerobic training of moderate intensity with training fraction of 65% to 75% of each subject's maximum heart rate obtained from the cardiopulmonary exercise test. This program had been applied for two months three times per week. The result of this study revealed that two months of supervised aerobic exercise training produced a significant improvement in most of the cardiopulmonary fitness indices. Aerobic training had significantly reduced the resting heart rate by 9.8 %, the resting systolic blood pressure by 1.88%. The maximum systolic blood pressure had been reduced by 0.64%. This is in addition to the increase of the maximum heart rate by 9.86%, VO_2max by 44.6%, and forced vital capacity by 52.2 %.

The results of this study are supported by several previous studies as it had been reported that low- to moderate-intensity activities may improve cardio-respiratory fitness and assist in the prevention of the physical disability in older adults.[21,37] It had been also reported that brisk walking, if undertaken at moderate intensities and other popular forms of aerobic training provide a sufficient stimulus to improve cardio respiratory fitness, and result in improvements in health outcomes and aerobic capacity in healthy individuals.[19] Older adults who participate in 20 to 30 minutes of moderate-intensity exercise on most days of the week have better physical function than older persons who are active throughout the day or who are inactive. Any type of physical activity is better than no activity for protection against functional limitations, but exercise provides greater benefit for physical capacity[4].

The age-associated decline in aerobic exercise capacity is partially reversible by endurance exercise training. Moderate-intensity endurance exercise training increases aerobic cardiorespiratory capacity mediated, in part, by improvement of stroke volume and left ventricular performance in older subject. Cardiac adaptations in older endurance trained subjects are characterized by volume-overload left ventricular hypertrophy and enhancement of left ventricular systolic performance at peak exercise. These adaptive responses contribute to enhanced stroke volume at peak exercise in older endurance trained subjects.[23] It was also proved that up to one third of the age-related decline in aerobic capacity (VO_2max) can be reversed with prolonged aerobic training[5].

The significant increase of the maximum oxygen consumption noted in this study could be attributed to the ability of aerobic exercise training to increase the amount of oxygen consumed at maximal effort, possibly because of increased availability of oxygen provided by the circulation, increased uptake by the skeletal muscles or both. Desirable changes in homodynamic, hormonal, metabolic, neurological and respiratory functions are also associated increased exercise tolerance.[19,24] Early studies suggested that VO_2max. increases about 15% to 25% with aerobic training that is primarily the result of an increase in blood flow to the active muscle mass because of an increase in maximal cardiac output. Changes within muscle also contribute to this increase, primarily the increases in capillarization, myoglobin, and oxidative enzyme activity.[2] It was also stated that those with a higher self-reported walking level had a better VO_2max, every 1 minute per day increase in habitual walking increases VO_2max by 0.096 (ml/min/ kg) and is possibly associated with a faster gait speed[37].

The significant reduction of the resting heart rate noted in this study after exercise training, could be attributed to, attenuating the sympathetic component of the baroreflex control of heart rate. Such attenuation could be postulated to three possible mechanisms, alteration at the level of effector's organ, altered central response to arterial baroreceptors afferent activity, and increase in the tonic inhibitory influence of the cardiopulmonary barororeflex. Both resting and submaximal HR are reduced after exercise training because of a decrease in sympathetic drive, with decreasing level of the circulating norepinephrine and epinephrine, accompanied by an increase in parasympathetic tone. It was documented that aerobic exercise training attenuates the sympathetic component of the baroreflex control of the heart rate[13,32].

Physical training results in decreased oxygen demand of the heart for a given level of total body oxygen consumption. This is manifested as a decrease in the product of HR multiplied by systolic arterial BP (an index of myocardial oxygen consumption) for a given level of exercise .Reduced oxygen demand and myocardial work are reflected in lowered heart rate and blood pressure at rest and general reduction in sympathetic tone. This is in addition to, increasing collateral arteries formation and reducing the rate of progression of coronary artery atherosclerosis[15].

The results of the present study showed that the mean values of forced vital capacity (FVC) was significantly increased from 2.1±0.67 L to 3.18±1.12 L. These results could be attributed to the ability of aerobic training to augment the respiratory response to exercise. This is accomplished by an increase in both maximal respiratory rate and maximal tidal volume. Ventilation remains about the same at rest and during submaximal exercise at the same power outputs but increases rather dramatically at maximal power output[36]. The improvement in forced vital capacity, could be attributed to increased pulmonary ventilation, as the lung can take in more air with each respiration[3]. It could result also from increasing efficiency of the external respiration where oxygen and carbon dioxide interchanged more efficiently between the lung and the capillaries on the alveoli. This in addition to increasing efficiency in the absorption oxygen per liter of the ventilation during exhausting work with increasing efficiency to eliminate carbon dioxide[9].

The significant reduction of the resting systolic BP from 135.55±8.1 mmHg to 133±7.75 mmHg (P-value < 0.05) and the significant reduction of the maximum systolic blood pressure from 149.5±8.26 mmHg to147.77±5.8 mmHg after training exercise, could be due to reduction in sympathetic over activity associated with increase in vagal activity[34]. Such reduction of the blood pressure could also be attributed to the ability of aerobic exercise training to restore vascular function in previously sedentary middle-aged and older men, as it has been approved that endothelial dysfunction, characterized by reduced nitric oxide availability, is a common characteristic of several diseases associated with aging, such as diabetes, hypertension, and dyslipidemia**.** The mechanism by which exercise protects the vascular endothelium is by preventing nitric oxide breakdown and preserving nitric oxide availability. Thus, aerobic exercise training can prevent the reduction in nitric oxide availability characteristic of impaired endothelium-dependent vasodilation that occurs with sedentary lifestyle in aging[7,16]. The local release of tissue-type plasminogen activator (t-PA) from the vascular endothelium is critical for vascular health and homeostasis. Endurance-trained older men did not demonstrate the age-related decline in the net release of t-PA that was evident in sedentary individuals of similar age. In addition, three months of aerobic exercise significantly increased the capacity of the vascular endothelium to release t-PA in older men. Thus, although endothelial t-PA release is reduced in older sedentary men, it appears that adapting a routine of continuous exercise may reverse this impairment[30].

Conclusion

"Furthermore, regardless of age, the cardiovascular system remains highly adaptable to training. Hence, because of the beneficial effects of increased level of activity and cardiorespiratory fitness on metabolic risk factors, cardiovascular disease, and all-cause mortality, regular aerobic activities should be recommended to middle-aged and older individuals"[21]. "Walking is the most common aerobic training modality utilized in rehabilitation programs. Thus, physicians and health professionals can prescribe brisk walking on a flat surface to their subjects with confidence that this intensity will achieve cardio-respiratory and health benefits"[18,28].

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الملخص العربي

تأثير التدريبات الهوائية على كفاءة القلب والرئة لدى السيدات المسنات

تهدف هذه الدراسة إلى معرفة مدى تأثير التدريبات الهوائية على كفاءة القلب والرئة لدى السيد ات المسنات . اشتملت هذه الدراسة علي أربعين سيدة مسنة يبلغ متوسط أعمار هن 67.1±3.7عاما ، حيث تم اختياريهن بطريق ة عشوائية من دور مسنين عدة بالقاهرة تحت إشراف أخصائيين في الأمراض الباطنية والمسنين . مارس الأشخاص جميعه ن تمرينات هوائية ذات الشدة المتوسطة بواسطة سير المشي ثلاث مرات أسبوعياً لمدة شهرين متصلين . وقد تم قياس معدل ضربات القلب أثناء الراحة و القصوى أثناء قياس كفاءة القلب والرئة بالتمرينات و ضغط الدم الانقباضي والانبساطي أثناء ألراحة وأثناء قياس كفاءة القلب و الرئة بالتمرينات وأقصى معدل لاستهلاك الأوكسجين ، كما تم قياس الكفاءة الرئوية لدى كل سيدة قبل وبعد انتهاء البرنامج ألتأهيلي مباشرة . وقد أظهرت هذه النتائج وجود زيادة ذات دلاله إحصائية لمعدل ضربات القلب القصوى وأقصى معدل لاستهلاك الأوكسجين والكفاءة الرئوية . بينما أظهرت هذه النتائج وجود نقص ذو دلاله إحصائية في معدل ضربات القلب أثناء الراحة ، وضغط الدم الانقباضي أثناء الراحة وأثناء المجهود مع عدم وجود تحسن ذو دلالة إحصائية في ضغط الدم الانبساطي أثناء الراحة وأثناء المجهود .

الكلمات الدالة : الشيخوخة – التدريبات الهوائية – الكفاءة الرئوية .