Original Article

SURVEY THE EFFECT OF AEROBIC EXERCISE ON AEROBIC CAPACITY IN PATIENTS WITH CORONARY ARTERY DISEASE (CAD)

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ABSTRACT

Objective: Increased aerobic exercise capacity appears to reduce both all-cause mortality and cardiovascular disease mortality. Physical exercise to improve maximal oxygen consumption (VO_{2max}) is thus strongly recommended, however evidence regarding the most efficient training intensity for patients with coronary artery disease (CAD) is still lacking. The purpose of this randomized study was to assess the effects of aerobic exercise for increasing VO_{2max} in stable CAD-patients.

Methodology: Thirty stable CAD-patients were randomized to supervised walking 30 min three times a week for 10 weeks. Before and after training VO_{2max} was predicted from Bruce treadmill test.

Results: Before training VO_{2max} was 35.2±4.32ml/kg/min and after training the mean Vo_2max was 43.1±3.4ml/kg/min. This difference was significant ($p<0.05$).

Conclusions: Aerobic exercise is effective for increasing VO_{2max} in stable CAD-patients. As VO_{2max} seems to reflect a continuum between health and cardiovascular disease and death, the present data may be useful in designing effective training programmes for improved health in the future.

KEY WORDS: Coronary artery disease, Aerobic exercise, Maximal oxygen consumption (VO_{2max}).

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INTRODUCTION

Higher levels of physical activity and fitness appear to reduce all-cause mortality and cardiovascular disease (CVD) mortality.[1-6] Physical exercise is thus strongly recommended in both primary and secondary prevention of CVD.[7-11] Peak aerobic exercise capacity is found to be the strongest independent predictor of mortality compared with other established risk factors among both healthy individuals and those with CVD[12] More specific, peak aerobic exercise capacity directly measured as maximal oxygen consumption (VO_{2max})was recently found to be the single best predictor of both cardiac and all-cause deaths among patients with established CVD[13]

For health promotions, patients with coronary artery disease (CAD) are recommended to regularly exercise at a mild to moderate

levels.[7-9] However, aerobic exercise training programmes are most often carried out at low-to-moderate intensities.[14] Both walking and vigorous exercise were found to be equally effective in increasing aerobic capacity and reduce cardiovascular risks.[15-21] However, two large cohort studies found that higher intensity of physical activity was related to reduced risk, as reflected by an inverse association between exercise intensity and coronary heart disease incidence in men.[22,23]

As aerobic exercise capacity seems to reflect a continuum between health and cardiovascular disease and death, it is important to design effective programmes for exercise-induced gains of VO_{2max} for patients with cardiovascular risk. Previous studies investigating the influence of different exercise intensities for improvements of VO_{2max}.[14] The aim of the present study was therefore to assess the effects aerobic exercise programmes of walking. The hypothesis was that aerobic exercise at low intensity (walking 30min three times a week for 10 weeks) is effective for increasing aerobic capacity in stable CAD-patients.

METHODS

Thirty eligible participants were enrolled in the study in August 2005 and the study was accomplished in December 2006. All patients had undergone a medical investigation for CAD at Jamaran Heart Hospital of Baqiatallah Medical Science University, within one year prior to the study (Table-I). Inclusion criteria were angiographically documented CAD in at least one major epicardial vessel. In addition, subjects had clinical evidence of CAD in the form of previous myocardial infarction, significant stenosis treated with coronary artery bypass surgery (CABG) or percutaneous coronary intervention (PCI), or ischaemia in exercise-electrocardiogram (ECG).

The study was accomplished according to the Declaration of Helsinki. The regional committee for medical research ethics approved the study protocol. Written and informed consent was obtained from all subjects at the beginning of the study. Before prediction of VO_{2max} the subjects were informed about the test, and instructed to exercise to their maximum limit. A standard 12-lead ECG was recorded at rest and at the end of each work level, and patients were stopped if any indication for terminating testing according to current guidelines took place.[9] To familiarize with Bruce treadmill test, the test started on a flat treadmill where participants learned to walk without grasping the handrails. As soon as they could walk properly, the speed and inclination was individually adjusted (2.74 -12.07km.h^{-1} and 10–28%) for a 3-minute warm-up. After the warm-up period using a Bruce protocol where the speed and the incline was increased every three minute until HR>220-age or patient be fatigued. Patients were walking during the study. Heart rate was continuously recorded using a Polar Sport Tester (Polar Electro OY, Finland) and maximum attainable heart rate (HR peak) was determined.

The patients met for training three times per week for 10 weeks under supervision of an exercise physiologist. The patients were instructed not to add any leisure exercise during the study period. Training consisted of walking.

All values are expressed as mean±standard deviation (SD). Changes before and after training were assessed using the paired sample t test. A two-tailed $P<0.05$ was accepted as statistically significant for all tests.

RESULTS

Patients demographics are given in Table-I with mean age of 45.2±5.6 years. The VO_{2max} increased significantly after training (Fig-1). Before training VO_{2max} was 35.2±4.32ml/kg/min and after training reached to 43.1±3.4ml/kg/min (Table-II). This difference was signifi-

Table-I: Patients demographics

Variable	*Meanmean±SD*	*Max*	*Min*
Age (Years)	45.2±5.6	32	54
Weight (kg)	72.3±6.2	62	83
Height (cm)	166.1±8.8	154	182
BMI	25.3±6.2	19.3	33.4

Table-II: Homodynamic parameters in patient with CAD

Status variable	*Before training mean±SD*	*After training mean±SD*
Vo2max ml/kg/min	35.2±4.32	43.1±3.4
Time Minutes	8.2±1.4	11.1±2.3
Distance Meters	822.3±120.3	1126.7±230.2

cant (p<0.05). The improvement after training was significantly greater compared to the before training. HRmax after training significantly reduced. There were detectable changes in resting blood pressure and resting heart rate in patients after the training period. The average time for completing test before training was 8.2±1.4 minute and after training was 11.1±2.3 minutes (Fig-2). Total distance before training was 822.3±120.3 m and after training reached to 1126.7±230.2m. This differences were significant (P<0.05).There were no episodes of cardiac events during the study.

DISCUSSION

The results of this randomized controlled study demonstrate that aerobic exercise is superior for increasing VO_{2max} in stable CAD-patients. Although VO_{2max} increased after 10 weeks of training, the improvement was significantly larger in the men. With regard to the total amount of work performed, this study solely points out aerobic exercise as a key factor for increasing aerobic capacity in this

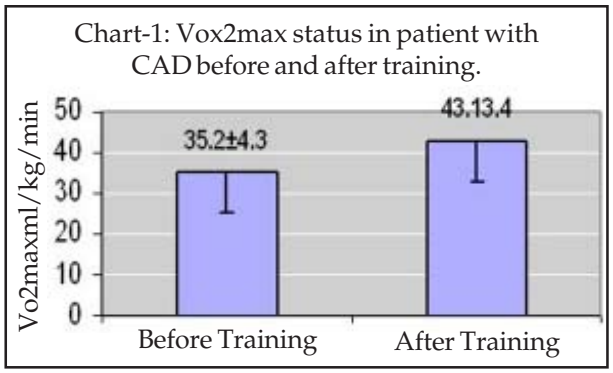

Figure-1: Maximal oxygen consumption (VO_{2max}) before and after aerobic exercise training in patient with CAD.

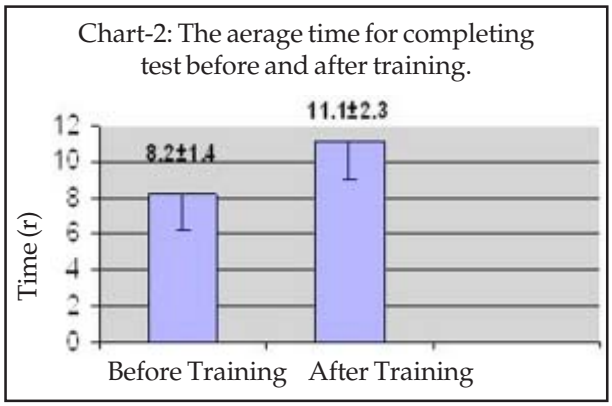

Figure-2: Time before and after aerobic exercise training in patient with CAD

patient group. In view of the prognostic importance of increasing VO_{2max} for this patient group, aerobic exercise may be considered in future rehabilitation programmes.

The present study is one of few where CAD-patients are performing aerobic interval exercise 30 minutes three times a week for 10 weeks throughout the whole training period. Since all subjects exercised with a heart rate monitoring device, the load of the treadmill could progressively be adjusted to keep the relative exercise intensity constant as training adaptations occurred. The improvement of after training compared to before training reflects the importance of aerobic exercise when determining the increase of VO_{2max}. Two earlier studies involving CAD-patients have employed aerobic interval exercise with elements of the high intensity as in the present study, both with a tremendous increase of $VO_{2max.}$[27,28] The results of these studies showed that 12 months exercise at an intensity of 50–95% of VO_{2max} carried out three to five times per week produced an improvement of 37–42%. The longer training period, along with the large dispersion in intensity and various numbers of training sessions per week, makes these results difficult to compare to the present study. These studies however demonstrate that high aerobic exercise intensity is associated with a large improvement of VO_{2max}.

The aerobic exercise program was chosen to be aerobic interval exercise because this training method has been employed by our research

group in healthy individuals, yielding great improvements of VO_{2max} in a relative short time period.[25] This program was selected because it is typically used in training studies involving CAD patients.[14] Adachi et al,[30] compared 29 patients with previous myocardial infarction performing walking exercise over eight weeks. The VO_{2max} increased by 17%. These findings support our study with regard to the fact that aerobic exercise being more suitable for increasing VO_{2max} compared to higher intensity exercise. Contrary to these studies, Blumenthal et al[31] did not detect differences between moderate intensity and low intensity exercise after 12 weeks of training among 45 patients with myocardial infarction. The VO_{2max} increased by 11% within the high intensity group and 14% in the low intensity group, but the differences were not statistically significant. In sum, these studies indicate that aerobic exercise is more suitable for increasing VO_{2max}.

The initial VO_{2max} of the patients in our study was 35.2±4.32ml/kg per min, which is higher compared to the other studies evaluating aerobic exercise in cardiac patients (18.7–25.3ml/kg per min).[29-31] Thus, the improvement of VO_{2max} after considerable training when calculating percentage improvement from such a higher baseline value. In fact, VO_{2max} increased after training. To ensure that exercise is conducted at the proper intensity, it is important that patients are exercising close to their maximal effort on the initial VO_{2max}-test. If not, the reported exercise intensities are likely overestimates of the actual ranges. Hence, the term VO_{2max} was used instead of VO_{2peak} to describe exercise capacity throughout the study. The researchers state that use of the Bruce protocol with relatively large and uneven work increments, made several subjects exceeding their anaerobic threshold in the first 3-min stage.[29] Work rate increments that are too rapid may result in reduced exercise capacity and it is suggested that individualized protocols with estimated test duration of 8–12 minutes are optimal.[24] Adachi et al,[30] carried out the VO_{2max}-test on bicycle ergometers, which are reported to produce VO_{2max}-values that are 6–25% lower compared to treadmill exercise.[24] However, aerobic exercise is clearly beneficial in lowering mortality compared to a sedentary lifestyle, and current guidelines suggest that the incidence of sudden cardiac arrest across a variety of activities, except jogging, is similar to that expected by chance alone.[9] Exercise is also shown to be a potent trigger of myocardial infarction.[33-35] The adjusted relative risk of myocardial infarction during or soon after exertion have been found greater in persons who do not regularly participate in physical activity[34,35] and it is thus of great importance to get this group more active. However, selected exercise testing should be performed at the discretion of a physician before vigorous exercise in patients with known cardiovascular problems.[36] For stable CAD-patients in particular, Hauer et al,[37,38] demonstrated that adherence to prescribed target heart rate up to 95% of HR_{peak} (90% VO_{2peak}) reached during symptom-limited exercise testing is associated with very few ischaemic episodes even during high intensity exercise training. More studies are however needed to evaluate the comparative efficacy and safety of possible detrimental effects of high intensity exercise vs. other modes of exercise in a non-selected population of CAD-patients.

As increasing VO_{2max} is found to be a major determinant of increasing functional capacity and thereby survival,[12,13] this type of exercise may thus be employed to optimize the exercise component of rehabilitation programmes for stable CAD patients in the future.

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