Cardiovascular Topics

Effect of resistance training on cardio-respiratory endurance and coronary artery disease risk

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Summary

Coronary artery disease (CAD) represents a major medical problem in Western society and is a considerable cause of morbidity and mortality in South Africa. In recent years, epidemiologists have made extensive efforts to define the most common risk factors for CAD and propose preventative measures to limit the spread of the disease. Despite the increasing realisation of the importance of resistance training, the literature has focused primarily on aerobic modes of exercise and their effects on risk for CAD. The aim of this study was to determine whether resistance training could alter cardio-respiratory endurance (VO_{2max}), and thus reduce CAD risk.

A quantitative, experimental, comparative research design incorporating a pre-test, a treatment period and a post-test was used. Twenty-eight untrained male volunteers were age matched (mean age: 28 years and seven months) and randomly assigned to either a non-exercising control group (*n* = 15) or a resistance-training group (*n* = 13). The study demonstrated no statistically significant change in VO_{2max} for the control group from their pre-test (25.097 ml/kg/min) to their post-test (23.778 ml/kg/min) ($p = 0.201$). However, resistance training significantly ($p \leq 0.01$) increased the VO_{2max} from 26.674 ml/kg/min to 30.981 ml/kg/min ($p = 0.004$). Additionally, the difference between the pre- and post-test of the control and training group, respectively, demonstrated that the control group's mean VO_{2max} was significantly lower than that of the resistance-training group ($p = 0.001$).

Although not all studies have demonstrated significant increases in VO_{2max} following resistance training, the results of this study showed that eight weeks of resistance training were sufficient to result in a significant improvement in VO_{2max}. This suggests that an exercise programme that includes resistance training results in a composite of physical and physiological improvements necessary to impact favourably on risk for CAD.

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Coronary artery disease (CAD) represents a major medical problem and is the most considerable cause of morbidity and mortality in Western societies, and in particular South Africa.[1] In recent years, epidemiologists have made extensive efforts to define the most common risk factors for CAD and propose preventative measures to limit the spread of the disease. Several modifiable risk factors for CAD have been identified, the most significant of these including smoking, hypertension, hyperlipidaemia and physical inactivity.[2-4]

Since the 1950s, there has been a steady accumulation of data from both observational studies and clinical trials, identifying a lack of regular physical activity as a major independent risk factor for developing CAD. Until recently, physical inactivity was not considered to be one of the primary risk factors in developing CAD,[7] but it is now regarded by some as the most prevalent of the risk factors.[5,6] At any level or combination of risk factors for CAD, individuals who are sedentary are at a greater risk than their physically active counterparts. Physical inactivity carries a risk similar to that of smoking, dyslipidemia or hypertension; the relative risk of death associated with lack of cardio-respiratory endurance (VO_{2max}) (3.44 for men, 4.65 for women) is greater than the relative risk associated with cigarette smoking (2.60 for men, 2.08 for women), hypercholesterolemia (1.74 for men, 3.24 for women), a family history of CAD (1.60 for men, 1.50 for women) or elevated glucose levels (2.74 for men, 3.73 for women).[8]

Literature on the effects of exercise training on risk factors for CAD has focused primarily on aerobic modes of exercise, despite the increasing popularity in recent years of weight training or resistance training.[8-10] Notwithstanding its popularity, resistance training is not commonly endorsed as an appropriate mode of exercise for CAD risk-factor intervention. Although the specific cardioprotective benefits of aerobic training are well known, resistance training has additional benefits. Some of these benefits include increased muscle strength and lean tissue mass, the maintenance of metabolically active tissue in the elderly, and increased neuromuscular control and coordination.[4,11-13] The primary aim of the present investigation was, therefore, to investigate the response of the modifiable risk factor of cardio-respiratory endurance (VO_{2max}) to eight weeks of resistance training in sedentary males.

Much of the medical profession's aversion to resistance training relates primarily to the acute elevations in blood pressure achieved during this training, and to the fact that previous studies have shown no favourable effects on cardiovascular function.[11,14,15] MacDougall *et al*. demonstrated peak pressures as high as 480/350 mmHg during heavy resistance training.[16] However, Sparling *et al*. stated that the common or standard method to assess blood pressure is via indirect auscultation and does not reflect peak arterial pressures during actual lifting movements.[17] Furthermore, during 10 to 15 repetitions with a weight load of 40% of one repetition maximum (1-RM), arterial pressure was evaluated (directly via catheter in the brachial artery) and found to increase only modestly, with a mean systolic pressure ranging from 170 to 186 mmHg, depending on the exercise.[18] This finding was confirmed by Kelemen *et al*. when they demonstrated peak auscultation systolic blood pressures averaging 141 mmHg immediately following 10 repetitions of 40 to 60% of 1-RM.[19]

Any resistance-training programme utilising 40 to 60% of 1-RM, therefore, appears to be relatively safe for even cardiac patients. Additionally, Karlsdottir and co-workers have shown that despite elevations in blood pressure during resistance training exercise, there is no evidence of significant rest-to-exercise deterioration in left ventricular function during this exercise, even in patients with congestive heart failure performing moderate-intensity resistance-training exercise.[20]

Methods

Twenty-eight untrained male volunteers, with ages ranging from 20 to 35 years (mean age: 28 years and seven months), enrolled in the investigation upon approval from the Rand Afrikaans University. These subjects were age matched and randomly assigned (using a random-numbers table) to either a control (n = 15) or experimental group (n = 13). The subjects in both groups were inducted into this study following a scheduled introductory session during which retrospective questionnaires were completed regarding health status, medical history and lifestyle habits. The subjects were also provided with an explanation of the risks, benefits and procedures of the study, and were shown the proper technique for each exercise used in the testing and training sessions. Thereafter, informed written consent was obtained.

All subjects were required to be sedentary for six months prior to the study, and on no pharmacological agents known to affect VO_{2max}. They had to be weight stable for at least six months prior to the study, free of medical conditions prohibiting exercise, and all subjects had to be male. This gender choice was because men and women can differ by 15 to 25% in their VO_{2max}. This age group was selected since VO_{2max} decreases by 8 to 10% per decade. Sedentary subjects were used as physical activity is one of the major modifiable risk factors for CAD, and physical inactivity is considered the most prevalent CAD risk factor. Also, trained subjects would have had a ceiling effect, which means their improvements would not be as obvious as in untrained (sedentary) subjects.

Technical information

VO_{2max} was measured before and after the eight-week experimental period, using a continuous submaximal cycle ergometer test.

Experimentally, subjects were required to train three times per week for 60 minutes, over the eight-week period. The sessions commenced with five minutes of easy cycling at a heart rate of less than 100 beats per minute, and stretching. The resistance-training exercises included shoulder shrugs, lateral shoulder raises, seated chest presses, latissimus dorsi pull-downs, seated rows, biceps curls, triceps extensions, crunches and leg presses, which were performed at 60% of the individual's estimated 1-RM. Each exercise was performed for three sets of 15 repetitions, and for crunches, three sets of 60% of the maximum number of repetitions were performed. The sessions were concluded with five minutes of easy cycling at a heart rate of less than 100 beats per minute.

Members of the control group were instructed to maintain their usual activities and not to take part in any form of structured exercise during the experimental period. VO_{2max} was measured before and after the eight-week experimental period using the YMCA cycle ergometry protocol. As with the experimental group, they were also not given any advice on their diet, alcohol intake and smoking behaviour over the experimental period.

Statistics

The study made use of the dependent and independent samples t-test and a 99% confidence level ($p \leq 0.01$). The statistical package for social sciences (SPSS) II was used.

Results

For the control group, the study demonstrated no statistically significant change in mean VO_{2max} from their pre-test (25.097 ml/kg/min) to their post-test (23.778 ml/kg/min) (p = 0.201). However, the resistance-training group's mean VO_{2max} increased by 13.902% from 26.674 ml/kg/min to 30.981 ml/kg/min (p = 0.004). The difference between the control and training group's respective pre- and post-test differences demonstrated that the control group's mean VO_{2max} was statistically significantly different when compared to that of the experimental group (p = 0.001).

It should be noted that the positive changes observed in the resistance-training group could be directly due to training-induced mechanisms, or to indirect mechanisms such as the promotion of positive nutritional or behavioural changes associated with commencement of an exercise programme ('halo effect'). Should the improvements in VO_{2max} be due to positive nutritional or behavioural changes, the study would have demonstrated that resistance training has significant favourable effects on several other modifiable risk factors for CAD, and not only on VO_{2max}. For example, sustained weight loss (more than three years) has demonstrated blood pressure-lowering effects similar to those of pharmacological studies.[21]

Discussion

Specifically, 12 to 15 weeks of aerobic training results in a 10 to 30% improvement in cardio-respiratory endurance.[22] However, it must be noted that the minimum threshold required to develop cardio-respiratory endurance is not the same as that required to improve and maintain health.[23] In terms of body weight or fat loss, it is recommended that a minimal threshold of 1 440 kilojoules per session, performed three days per week, or 960 kilojoules per session, performed four days per week, equating to a weekly threshold of 3 840 to 4 320 exercise kilojoules, be undertaken.[23] This amount of exercise is essential to all levels of risk prevention for CAD, and it appears that lower levels of exercise are required to reduce risk than to improve fitness.[4,24]

Although the minimal amount of exercise required is unclear, even moderate walking, expending 4 200 kilojoules per week, can result in substantial benefits.[25] Furthermore, the thresholds for weight loss and for improvements in cardio-respiratory endurance and in chronic disease may be different.[23] In addition, we suspect that large volumes and long periods (i.e. days, weeks, months and years) of exercise training clearly define the metabolic processes that result in multi-benefit changes.

Although many studies have not demonstrated significant increases in VO_{2max} following resistance training,[9,10] the results of the present study showed that eight weeks of resistance training were sufficient to result in a significant 13.9% increase in VO_{2max}. These findings are consistent with those of several researchers who demonstrated a range of increases in VO_{2max} from 7.8 to 23.5% following a period of resistance training.[11,19,26]

Conclusion

The present study suggests that an optimal training regime for the prevention of CAD and rehabilitation thereof might require both aerobic and resistance components. This notion is corroborated by Banz *et al*., who claim that both resistance and aerobic training appear to be effective in reducing numerous risk factors for CAD, with each mode of exercise providing unique benefits.[26] However, the sheer diversity of the different methods of exercising is a source of complication when attempting to determine whether exercise can favourably alter an individual's risk for CAD and VO_{2max}.

An 'optimal' combination of exercise dose, workload, intensity and repetitions still eludes researchers in this area of study. It has been suggested that the total workload (training volume and duration of participation) is the key factor that determines the effects of exercise training on risk factors for CAD.[27] Even though the precise combination of exercise and the mechanisms whereby exercise may reduce risk for CAD and improve VO_{2max} are unknown, there is an evidence-based inverse linear dose response between the amount of exercise, and the incidence of CAD and mortality.[25] This eight-week resistance-training programme showed an indisputable increase of 13.9% in VO_{2max} and may have decreased the risk of developing CAD.

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