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Association between Physical Activity and Coronary Artery Diseases: A Narrative Review

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Abstract

Introduction: Regular physical activity decreases the incidence of cardiovascular disease but the mechanisms determining this reduction are related to the modulation of classic risk factors and maintenance of endothelial function. This narrative review highlighted physical activity and exercise role on the prevention of CAD, which postulates that exercise is influenced by variables at multiple levels.

Methods: A systematic literature search of RCTs was conducted in PubMed Web of Science, and Cochrane Library. Moreover, reference lists of retrieved articles were hand searched for trials which may meet inclusion criteria but cannot be retrieved in the initial searching. The literature search was performed independently by two reviewers. Irrelevant studies and duplicates were removed, and then titles and abstracts were fully screened. We decided not to include outcomes in the search string, in order to include a wide range of literature on the central subject, including only population and intervention.

Results: In the included studies, a total of 15 studies included in this review with a total of 1,272 participants with a dropout rate ranging from 0% to 38%. The main reason for dropout was low compliance with exercise protocols or withdrawal of consent, rather than medical reasons. A total of six patients failed to complete the study because of angina, atrial fibrillation, pericarditis, or myocardial infarction. Most of the trials enrolled both male and female patients except four, which only recruited males.

Conclusions: Many studies recommended length, intensity, and duration of physical activity to prevent coronary artery diseases, as well as other cardiovascular diseases. Physical activity with at least 30 minutes of moderate-intensity physical activity on most days of the week reduce the risk of coronary artery diseases.

Keywords: Physical activity, Intensity, Cardiovascular, Coronary, Risk.

Introduction

Cardiovascular disease is the main cause of morbidity and mortality in western societies. Although traditional risk factors (hypertension, dyslipidaemia, diabetes mellitus, smoking) have a systemic atherogenic effect on the entire vasculature, local hemodynamic factors determine the distribution of atherosclerotic lesions [1]. Endothelial shear stress (ESS), the frictional force acting on the endothelium as the result of blood flow, represents a continuous stimulus eliciting structural and functional effects on the endothelium and plays a critical role in the development of atherosclerosis. Atherosclerotic lesions develop preferentially at areas with disturbed local hemodynamic factors, mainly in regions with low ESS, such as the inner curvature of coronary arteries or in the outer waist of a coronary bifurcation and downstream from a luminal obstruction where ESS is oscillatory [2]. In contrast, arterial regions with physiologic/ increased local flow and ESS are thought to be protected from atherosclerosis. In middle-aged men and women a range of behaviors have been linked to CHD including cigarette smoking, type and quantity of diet, and inebriation inducing levels of alcohol consumption [3].

Coronary artery disease (CAD) is the leading cause of death in men and women worldwide, responsible for 8.1 million deaths [4]. As the global burden of CAD rises, prevention of heart disease has gained heightened medical attention, and aggressive lifestyle and pharmacotherapeutic interventions are increasingly addressed in the literature. Approximately 30% of annual deaths in North America being attributed to CAD [5]. One potential mechanism used to explain this high mortality rate is the lack of exercise capacity among patients with CHD. Although recent evidence suggests that when compared with other known cardiovascular risk factors, exercise capacity is the strongest predictor of mortality among CAD patients, exercise adherence rates among this population continue to be poor across several contexts [6]. Multiple studies suggest that exercise decreases the risk of coronary artery disease (CAD) with the positive impact on both primary and secondary prevention being greater than 30%. Exercise-based cardiac rehabilitation has been associated with reduced both all-cause and cardiac mortality as well as hospital admissions. In addition, exercise-induced changes in flow-mediated dilation (FMD), an index of vascular function, do not correlate well with changes in traditional cardiovascular risk factors [7]. Exercise-induced hemodynamic alterations have been reported to play a major role in cardiovascular disease risk reduction, leading to direct effects on the vasculature that are athero-protective. Schematic and hypothetical representation of how hemodynamics during exercise may impact vascular phenotype [8]. The left panel represents hemodynamic stimuli that may be associated with antiatherogenic effects, which include a predominant antegrade shear pattern and cyclic, intermittent elevations in arterial blood pressure (or pulse pressure). These hemodynamic stimuli are related to outward remodeling and a smaller arterial wall thickness, while some observed (in boldface) antiatherogenic genes have been shown to be upregulated, and proatherogenic genes are hypothesized (in italics) to be downregulated under these conditions.

These stimuli are believed to contribute to inward remodeling, thickening of the artery wall and increased expression of proatherogenic genes and downregulation of genes involved on the pathway [9]. As primary prevention, regular physical activity decreases the incidence of cardiovascular disease. Endothelial dysfunction, which precedes coronary sclerosis by many years, is the first step of a vicious cycle culminating in overt atherosclerosis, significant coronary artery disease (CAD), plaque rupture, and, finally, myocardial infarction. In addition to classic risk factors, such as hypertension, smoking, diabetes mellitus, and hypercholesterolemia, physical inactivity has been identified as an independent predictor for the development of CAD [10]. In contrast, regular physical activity seems to be effective in the primary prevention of CAD via the modulation of classic risk factors and maintenance of endothelial function.

Furthermore, exercise training seems to attenuate disease progression and improve event-free survival in the secondary prevention of CAD [10]. Mechanistically, numerous studies suggest that regular physical activity partially reverses endothelial alterations: it enhances the vascular production of NO, decreases the generation of reactive oxygen species by activating endogenous progenitor cells, induces the CPC-mediated formation of new vessels by vasculogenesis, and promotes myocardial expression of vascular growth factors (which induce the remodeling of pre-existing capillaries and arterioles [11].

Despite this, however, the real magnitude of association between physical activity and CAD has not been completely defined, as previous metanalyses did not specifically target the role of physical activity in the primary prevention of CAD. It is difficult to measure physical activity in an observational study designs. This narrative review highlighted physical activity and exercise role on the prevention of CAD, which postulates that exercise is influenced by variables at multiple levels.

Methods

A systematic literature search of RCTs was conducted in PubMed Web of Science, and Cochrane Library up to October 2022. The search was performed using two blocks of terms (high-intensity interval training, aerobic interval training) and CAD (coronary artery disease or myocardial infarction. Moreover, reference lists of retrieved articles were hand searched for trials which may meet inclusion criteria but cannot be retrieved in the initial searching. The literature search was performed independently by two reviewers. Irrelevant studies and duplicates were removed, and then titles and abstracts were fully screened. Any disagreement between the reviewers for inclusion was resolved by the senior authors. Data were extracted by two reviewers independently using a standardized form and checked by the third reviewer. The disagreement was discussed and resolved by consensus and consultation with the expert group. After searching reference lists of retrieved articles for trials which may meet the inclusion criteria of our analysis, 25 articles were eventually included. No filter was set to select randomized clinical trials, since the decision had been made to initially include more studies, to widen the scope of the literature on the subject reviewed. We decided not to include outcomes in the search string, in order to include a wide range of literature on the central subject, including only population and intervention.

Results and discussion

A total of 15 studies included in this review with a total of 1272 participants with a dropout rate ranging from 0% to 38%. The main reason for dropout was low compliance with exercise protocols or withdrawal of consent, rather than medical reasons. A total of six patients failed to complete the study because of angina, atrial fibrillation, pericarditis, or myocardial infarction. Most of the trials enrolled both male and female patients except four, which only recruited males.

Studies that did not examine one of these three outcomes were not included in this review. When more than one published report was generated using the same cohort and the same outcome, only the most recently published results were used. For example, two studies pf occupational activity both reported on the same outcomes in the same cohort. To use as much of the available information as possible, we included studies that reported on each gender separately. For some studies and some outcomes, the leisure results were used in preference to the work activity results. For several studies, only a relative risk and a p value were provided. With only one exception, when we pool occupational studies using coronary heart disease, coronary heart disease death, or angina pectoris separately according to quality score, we observe higher relative risk estimates for all outcomes among the studies with higher quality scores than among those with lower quality scores [12, 13]. The included studies presented separate relative risk estimates for a "moderate" activity comparison group and a "sedentary" comparison group, with the "highly active" group as the reference for both [14]. The relative risks from the comparisons of the vigorous activity groups with the moderate activity groups were

combined, for only those studies that present separate relative risks for moderate and sedentary comparison groups. On another hand, the relative risks from the studies that do not separate moderate from sedentary comparison groups were also combined [15]. Combination of the relative risks from the studies that separate moderate and sedentary comparison groups, using only the sedentary groups [16, 17]. The included studies described seven separate desirable features of a physical activity measure, four desirable components of a coronary heart disease measure, and five desirable aspects of the epidemiologic methods, for a total of 16 components [18, 19]. It was not uncommon for two studies with the same objective score for a component to receive different ratings. The sub-scores for the physical activity measure on both cohorts were 4 out of a possible 14, yet the measure for the postal workers was rated unsatisfactory while the measure for busmen was rated satisfactory [20]. Physical exercise is an extremely important non-pharmaceutical tool for treating AMI, both for preventing risk factors and for increasing VO2peak. With regard to efficacy, aerobic exercise appears to deliver similar results in terms of VO2peak, compared to other methods, such as, for example, combined exercise (aerobic + strength exercises in the same session), and superior results to strength exercises [21].

Recent epidemiologic studies have attempted to deal with these problems with varying degrees of success. Most of these studies reported that physically active workers had one-third to three-fourths fewer total or fatal CHD events than the least active. In addition, leisure time activities were not considered [22]. Furthermore, direct observations revealed that job-titles used to assess physical activity did not accurately reflect actual energy expenditure. For example, lumberjacks consumed more saturated fat, smoked slightly more, and were of lower socioeconomic status than farmers. They found a 10% lower CHD and total mortality rate in farmers than in non-farmers [23]. Iowa farmers were twice as likely to be more physically active than non-farmers, were more fit by exercise testing, and had a higher caloric intake consistent with their greater energy output. However, a significantly lower consumption of tobacco and alcohol in farmers confounded the results [24]. In addition, further evaluation of a representative sample of the study population revealed no significant difference in average body weights and blood cholesterol and triglyceride levels between the two activity groups. The relative risk of total CHD for men engaged in sedentary work was 2.5 times that of men engaged in physical work. The corresponding risk ratio in women was 3.1. Cargo handlers who loaded and unloaded ships were classified as physically active in contrast to foremen and clerks, considered less vigorous. The CHD death rate per 10,000 man-years of work was about half for the group of men who extended 8500 or more kcal per week at work as compared with the rate of less physically active men. The rate for sudden cardiac death was about one-third as high for the more active workers. The differential in CHD deaths remained statistically significant when adjustments were made for other risk factors, namely, cigarette smoking, systolic blood pressure, relative body weight, and glucose tolerance. The risk in the more active men was generally about one-half to two-thirds of the least active. During the next 8 years of follow-up, those who performed vigorous exercise, such as sports, jogging, rapid walking, hiking, hill climbing, or heavy work around the house, garden, or garage, had about half the rate of initial heart attacks and about one-third the rate of CHD mortality as did their colleagues who reported no vigorous exercise [25].

Moreover, the CHD incidence and mortality rates increased significantly with age only in the physically inactive group. An evaluation of a representative sample from this cohort revealed no significant difference in other conventional risk factors between the exercise and non-exercise group. However, the frequency of resting electrocardiographic abnormalities was twice as high in the inactive group. The age-adjusted incidence rate of CHD was inversely related to the energy expenditure by walking, stair-climbing, and playing sports and to the composite energy expenditure in kcal per week as determined by responses to mail questionnaires [26]. Men expending fewer than 2000 kcal per week were at 64 per cent higher risk than their ex-classmates who were less active. No additional reduction in CHD rate was found in men expending more than 2000 kcal per week. CHD risk was further increased in men with low levels of physical activity if other risk factors, such as cigarette

smoking, hypertension, diabetes mellitus, obesity, or a parental history of a heart attack, were present. The association between risk of CHD and level of physical activity remained strong when adjustments were made for these confounders [27].

A significant inverse association was found between acute coronary events and habitual (defined as > 8 months per year) walking, cycling, and gardening. This was not true if these activities were performed only occasionally or on a seasonal basis (4 to 8 months per year). The relative CHD risk adjusted for other conventional CHD risk factors was 2.2 for those workers who had below-average exercise capacity at baseline, reflecting below-average physical fitness. Below-average physical fitness in combination with at least two other risk factors (that is, above median serum cholesterol level, elevation of systolic blood pressure, or cigarette smoking) increased the risk ratio [28]. The incidence of myocardial infarction in both the heavy-and moderate-activity category was about half that of the light activity group; furthermore, the least active men had a 4.5 times greater mortality rate following infarction than the most active men. These differentials persisted after adjustments were made for body weight and smoking. The risk of cardiac arrest was 55 to 65% lower in the persons in the two upper quartiles of high-intensity physical activity than in persons doing no high-intensity physical activity. Increased leisure-time physical activity, but not job activity, was found to be associated with decreased risk of CHD death, even when there is adjustment of cigarette smoking and hypertension [29].

Other risk factors, particularly serum cholesterol levels and dietary intake of saturated fat, appeared to better explain differences in CHD rates among countries. Only three of the seven countries showed an inverse association between physical activity (mostly occupational) and CHD, while in the others (for example, the United States and Finland), there was no apparent association [30]. In Finland, the country with the highest incidence and mortality from CHD in the study, the 10-year follow-up revealed no difference in CHD mortality between men classified as sedentary as compared with the most active, while the rate in the moderately active men was unexplainably twice that of the other two classes [31]. Re-evaluation of the original 10-year data revealed that for men age 50 to 69 years CHD incidence was clearly associated with sedentary habits. After adjustments were made for age, relative weight, serum total cholesterol, diastolic blood pressure, and smoking, the relative risk of low physical activity at work was 1.5 in men and 2.4 in women as compared with more active people. Risk of CHD was also increased in those with low levels of combined job and leisure-time physical activity. There was a decreased risk of CHD among men active during leisure time for the year prior to the event, but this association disappeared when adjustments were made for other conventional risk factors.

The latter findings are supported by recent experimental data from non-human primates receiving atherogenic diets in which regular exercise reduced the severity of coronary atherosclerosis. The physically active men had significantly larger coronary artery luminal areas as compared with light workers, in agreement with experimental findings in exercised rats and monkeys. In addition, the active men were less likely than inactive men to have total occlusions of major coronary arteries despite advanced atherosclerosis [31].

Conclusions

Many studies recommended length, intensity, and duration of physical activity to prevent coronary artery diseases, as well as other cardiovascular diseases. Physical activity with at least 30 minutes of moderate-intensity physical activity on most days of the week reduce the risk of coronary artery diseases. For most healthy adults, moderate-intensity activities represent the equivalent of brisk walking at 3 to 4 mph (3 to METs). In contrast, previous recommendations typically have prescribed vigorous exercise, for at least 20 minutes continuously, at least three times a week. Vigorous exercise increases the heart rate and causes sweating; such activities generally require 6 or more METs and include jogging and running.

Conflict of interests

The authors declared no conflict of interests.

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