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Prevention and Management of Cardiovascular Disease through Physical Exercise

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Abstract: *Cardiovascular disease is rapidly increasing in incidence and prevalence worldwide. As a result there is growing concern not only about the rapid increase but in the changing pattern of these diseases that are now appearing in developing countries. This change in pattern is partly due to the sedentary lifestyle now occurring in these countries of economic transition. It is being projected that with this epidemiologic shift, the burden of cardiovascular disease will be greater in the years to come. Hence experts advocate the importance of applying a life course approach to the prevention and control of these diseases. Physical exercise plays a major role in the prevention and management of cardiovascular disease. It not only addresses the sedentary lifestyle but is also able to control most cardiovascular disease risk factors. If health care professionals can ensure compliance to prescribed physical exercise, then the much advocated life course approach to prevention and control of cardiovascular disease has been identified.*

Keywords*: Cardiovascular disease, physical exercise, physical activity, prevention.*

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I. Introduction

There is a rapid increase in the incidence and prevalence of cardiovascular disease worldwide[1]. Epidemiologically, the concern is not only about the sudden increased rate of changes in the pattern of these diseases, but also their appearance earlier in life[2]. Furthermore the shift seems to be much greater in countries of economic transition. Considering the tendency to sedentary life style in these countries, the burden of cardiovascular disease and diabetes will be greater in the years to come. Hence experts advocate the importance of applying a life course approach to the prevention and control of these diseases[3,4].

Physical exercise plays a major role in the prevention and management of cardiovascular disease through its impact on both physiological and psychological state. Regular physical activity using large muscle groups, such as walking, running, or swimming, produces cardiovascular adaptations that increase exercise capacity, endurance, and skeletal muscle strength. Habitual physical activity prevents the development of coronary artery disease (CAD) and reduces symptoms in patients with established cardiovascular disease[5]. Physical activity promotes fat loss; it has an impact both on the amount of body fat, and fat distribution and preserves or increases lean mass. It also has a positive impact on blood pressure and lipid profile through decreasing systolic and diastolic blood pressure, increasing HDL-cholesterol and decreasing LDL-cholesterol and triglycerides.

There is also evidence that exercise reduces the risk of other chronic diseases including type 2 diabetes[6], osteoporosis[7], obesity[8], depression[9], and cancer of the breast [10]and colon[11]. Regular exercise has psychological benefits and could improve mood state, prevent anxiety and stress in addition to preventing depression[12-14]. The combined physiological and psychological well being of exercise, by reducing obesity and depression reduces central obesity which in turn could prevent and reduce metabolic syndrome and cardiovascular disease. The current recommendation from the Centres for Disease Control and Prevention (CDC) and the American College of Sports Medicine (ACSM)is that individuals should engage in 30 minutes or more of moderate-intensity physical activity on most (preferably all) days of the week[15].

This review summarizes the evidence for benefits of physical exercise in the prevention and management of cardiovascular diseases, provides suggestions to health care professionals for implementing physical activity programs for their patients by making useful recommendations to encourage active lifestyle. It focuses on aerobic physical activity and does not directly evaluate resistant exercises such as weight lifting, because most research linking exercise and cardiovascular disease has evaluated aerobic activity. Finally it identifies areas of future research on physical activity and health.

II. Prevention Of Atherosclerotic Vascular Disease Through Exercise

Prospective epidemiologic studies in the last half century have consistently documented a reduced incidence of CAD events in the more physically active[16] and fit[17] subjects. More recent studies have provided similar data by using measures of exercise capacity such as treadmill performance as an indicator of physical activity. The studies revealed that increased levels of physical activity were closely related to decreased rates of CAD. Multiple studies were prospective and thereby demonstrate appropriate sequencing because the lower physical activity levels preceded the development of CAD rather than resulted from the disease itself. In many studies, the lower rate of CAD was independent of other atherosclerotic risk factors. The results were also plausible and coherent with evidence demonstrating beneficial effects of exercise on atherosclerotic risk factors, myocardial function, coronary artery size and vasodilatory capacity, vascular tone and vulnerability to ventricular fibrillation. There was no clear evidence to show if withdrawal of physical activity increases CAD risk, although results from the Harvard Alumni Study suggest that college athletic activity is not protective in later years without lifelong physical activity[18]. Studies using the best designs and measurement instruments show the strongest relationships between physical activity and decreased CAD events, probably because superior assessment techniques limit inaccuracies in categorizing physical activity levels[17]. This is exemplified by the fact that studies on cardiorespiratory fitness, measured as treadmill performance times, and CAD show stronger associations than are seen in activity studies. This was probably because of the better classification by objective means of fitness rather than the relatively imprecise assessments of self-reported physical activity[17]. These epidemiological studies, combined with studies providing biological plausibility provide conclusive evidence that physical activity reduces the incidence of CAD.

III. Reduction Of Atherosclerotic Risk Factors Through Exercise

Atherosclerotic risk factors including elevated blood pressure, diabetes mellitus, insulin resistance, elevated triglyceride concentrations, elevated low-density lipoprotein cholesterol (LDL-C) concentrations, low high-density lipoprotein cholesterol (HDL-C) concentrations and obesity can be prevented and treated through physical exercise. The combination of physical exercise and weight reduction can reduce LDL-C levels and limit the reduction in HDL-C that often occurs with a reduction in dietary saturated fat[19]. The extent to which exercise reduces atherosclerotic risk factors is determined by the exercise intervention, the individual variation and whether exercise produces concomitant weight loss. The reduction in the risk factors may be large in some individuals thus obviating the need for other interventions. In general, the effect of exercise on reduction of atherosclerotic risk factors is substantially less than that achieved by pharmacotherapy but can be magnified by lifestyle changes such as changes in diet and weight loss.

The largest and most carefully controlled exercise trial, the HEalth, Risk factors, exercise Training, and Genetics (HERITAGE) study, included 675 normolipidemic subjects who participated in 5 months exercise training[20]. HDL-C increased by 1.1mg/dl (3%) among the 299 men studied, whereas triglycerides and LDL-C decreased by 5.9 and 0.9 mg/dl or 2.7 and 0.8%, respectively. Among the 376 women studied, HDL-C increased by 1.4mg/dl (3%), and triglycerides and LDL-C decreased by 0.6 and 4.4mg/dl or 0.6% and 4%, respectively. Individuals with baseline hypertriglceridemia [21] may have greater increases in HDL-C but few studies have addressed the effect of exercise in subjects with lipid disorders.

The effect of exercise on resting blood pressure[22] has been studied in at least 44 randomised controlled trials. The average reduction in systolic and diastolic blood pressure was 3.4 and 2.4mmHg respectively. Baseline blood pressure was an important determinant of the exercise effect. The average systolic and diastolic blood pressure decreased by 2.6 and 1.8mmHg in normotensives and by 7.4 and 5.8mmHg in hypertensives respectively suggesting that exercise may serve as the only therapy required in some mildly hypertensive subjects. There was no relationship between the weekly training frequency, time per session, or intensity of exercise training and magnitude of the blood pressure reduction, which suggests that the dose-response curve for exercise and blood pressure is flat.

Exercise also reduces insulin resistance and glucose intolerance, postprandial hyperglycemia, and possibly hepatic glucose output[23]. A review of 9 trials examining the effect of exercise training in 337 patients with type 2 diabetes reported an average reduction haemoglobin A1c of 0.5% to 1%[23]. The Diabetes Prevention Program demonstrated the powerful effect that physical activity and weight loss can exert in preventing the onset of type 2 diabetes in individuals at risk for this disease[6]. Compared with usual care, there was 58% reduction in the onset of type 2 diabetes over 2.8 years among individuals randomised to a lifestyle intervention that produced an average 4-kg decrease in body weight and 8-MET-h/wk increase in physical activity. The latter corresponds to an additional 593kcal of energy expenditure weekly or walking about 6 miles for a 70kg individual. The lifestyle intervention was also significantly more powerful than Metformin (850mg BID), which reduced the onset of type 2 diabetes by 31%.

Exercise is also an important adjunct to diet for achieving and maintaining weight loss in the obese. The National Weight Control Registry in America enrolled 3000 individuals who lost >10% of their body

weight and maintained this weight loss for at least 1 year[8]. The average weight loss of 30kg was maintained for an average of 5.5 years. Eighty-one percent of the registrants reported increased physical activity. Women and men reported expending 2445 and 3298 kcal weekly in such activities as walking, cycling, aerobics, running and stair climbing.

IV. Exercise For Treatment Of Patients With Coronary Artery Disease

Comprehensive exercise-based cardiac rehabilitation reduces mortality rates after myocardial infarction. This has been demonstrated by several meta-analysis[24,25]. A more recent comprehensive meta-analysis identified 51 randomised controlled trials of exercise based cardiac rehabilitation[25].Patients were included if they had sustained a myocardial infarction, had undergone coronary artery bypass grafting or percutaneous transluminal coronary angioplasty, had angina pectoris or had CAD identified by angiography. Supervised exercise training in these programs was generally 2 to 6 months' duration followed by unsupervised exercise[24,25]. The mean follow up was 2.4 years. Results were analysed according to whether the cardiac rehabilitation program consisted of exercise only or also included psychosocial and/or educational interventions[26]. Total mortality was reduced by 27% with exercise-only intervention and 13% with comprehensive rehabilitation. Cardiac mortality was reduced by 31% ($p < 0.05$) and 26% ($p < 0.05$) for the exercise only and comprehensive programs, respectively. Neither the exercise-only program nor the comprehensive intervention significantly reduced the rate of nonfatal myocardial infarction. Additionally rates of sudden cardiac deaths were not reduced. The reduction in death without a reduction in nonfatal reinfarction raises the possibility that exercise training enhanced electrical stability and reduced ventricular fibrillation[27] or reduced myocardial damage directly via such factors as ischemic preconditioning[28]. Many of the studies in this meta-analysis preceded most of the present treatments for CAD including widespread use of acute thrombolytic therapy, primary angioplasty, aggressive revascularization, β-adrenergic blockers, aggressive lipid management, and angiotensin converting enzyme inhibitors. Thus it is not clear whether exercise treatment after myocardial infarction would have great impact on mortality rates in the present era of cardiovascular disease management though the effects of medical treatment may be overestimated in medical interventions not involving exercise.

Exercise training is also useful for patients with angina pectoris who are not candidates for revascularization therapy because of disease not amenable to intervention, angiographically noncritical stenosis or patient preference. Early studies demonstrated that the symptomatic improvement in exercise tolerance after exercise training was primarily due to a reduction the heart rate and systolic blood pressure or rate pressure product (RPP). Some subsequent reports which demonstrated a reduction in the ischemic response measured as angina, ST segment depression[29] or nuclear and positron-emission tomography scanning perfusion defects[30,31] at a given RPP suggest that exercise training improved myocardial oxygen delivery.

V. Exercise For Treatment Of Patients With Heart Failure

Restriction of physical activity was recommended for patients with heart failure(HF) until the late 1970s and 1980s when it was recognised that exercise capacity in patients with left ventricular dysfunction could not be predicted by such parameters as intracardiac filling pressures and left ventricular ejection fraction. Numerous trials have demonstrated that both exercise testing and training of patients with HF appear to be safe. Exercise training benefits HF in several ways. The mean increase in the maximum rate of oxygen consumption during incremental exercise (peak VO_2) in 15 randomised controlled trials of exercise training that included 426 HF patients was 20.5%. The frequency, duration, and intensity varied among the trials, but all showed an increase in the average peak VO_2 between 12% and 31%[32]. In addition to improving exercise capacity, exercise training in HF has been shown to improve cardiac output at maximal workloads[33], improve mitochondrial size and density[34] increase skeletal muscle oxidative enzymes, reduce endothelial dysfunction[35], and decrease circulating catecholamines[36]. Exercise training has also been shown to improve quality of life in both men and women with moderate, chronic HF[37]. It is yet to be determined by large prospective trials whether these physiological adaptations will ultimately reduce morbidity and mortality in HF. One small trial showed a reduction in hospitalization and improved 1 year survival[38].

VI. Exercise For Treatment Of Patients With Peripheral Artery Disease And Claudication

Walking distance in patients with peripheral artery disease and exercise induced claudication can be effectively improved by progressive physical activity. Supervised exercise may serve as a primary therapy for many individuals with claudication if such a program is available and if claudication is the primary functional limitation. In a meta-analysis of 21 exercise programs for patients with claudication, It was demonstrated that after exercise training, average walking distance to pain onset increased by 179% or 225meters, and average distance to maximal tolerated pain increased by 122% or 397meters[39]. These increases in walking distance are greater than those reported for the most widely used agents for claudication, Pentoxyphyline and Cilostazol.

The greatest improvement with exercise training for claudication occurred with training to maximal tolerated pain, when training lasted at least 6 months, and when walking was the primary mode of exercise[39]. A review of randomised controlled trials suggests that the evidence favouring exercise training outweighs that for peripheral angioplasty in improving exercise tolerance in patients with claudication[40]. In contrast, a direct comparison of invasive treatment and supervised exercise training found improvement at 1 year only in invasively treated patients[41] so the issue remains controversial. In addition, no trials have examined the effect of exercise training on the need for revascularization or on subsequent cardiovascular events or mortality in patients with claudication.

VII. Risks Of Physical Exercise

When recommending physical exercise for the general populace and individuals with cardiovascular disease, certain risks need to be considered. Fortunately several strategies are effective at reducing risk when recommending physical activity. Available information suggests that physical activity in the range recommended by recent public health guidelines, such as the CDC/ACSM guideline[15] has an acceptable risk-to-benefit ratio. The most common risk of physical activity in adults is musculoskeletal injury[42,43]. Several factors affecting injury risk are modifiable and offer opportunities for risk management. Risk of injury increases with obesity[43], volume of exercise[42] and participation in vigorous exercises such as competitive sports[44]. Higher fitness[42], supervision, stretching exercises, protective equipments such as bike helmets, and well designed environments protect against injury. The general principle that volume of physical activity should be increased gradually over time is critical for reducing the risk of injury[15].

Vigorous physical activity acutely increases the risk of sudden cardiac death [45] and myocardial infarction[46] among individuals with both diagnosed and occult heart disease. A variety of congenital and acquired heart diseases like hypertrophic cardiomyopathy, aortic stenosis, coronary artery anormalies, and cardiomyopathies are associated with sudden death during vigorous activity in children and young adults[47]. Sedentary adults should avoid isolated bouts of unaccustomed vigorous physical exercise and should follow the standard recommendation to increase physical activity levels gradually over time.

VIII. Conclusion

This review has shown that there is sufficient evidence to promote physical exercise for the public and patient groups. For the public it would be a life course approach to the prevention and control of cardiovascular disease and for the patient as an adjunct to the treatment of cardiovascular disease. Physical exercise would be the best current strategy for prevention and management of cardiovascular disease at a reduced cost with minimal risk if performed according to the CDC/ACSM guideline[15]. However efforts need to be made to improve compliance to physical exercise in the populace.

IX. Recommendations

- The original American Heart Association (AHA) Statement on Exercise in 1992[48] was among the first documents to conclude that physical inactivity is a major CAD risk factor. Atherosclerotic vascular disease remains a major cause of death in many countries, hence it is important that health care providers support the implementation and maintenance of exercise programs for the public and their patients across the lifespan. Health care professionals should personally engage in an active lifestyle to familiarize themselves with the issues involved in maintaining lifelong physical activity and to set a positive example for patients and the public.

Recommendations to the public

Health care providers should assist in promoting physical exercise to the public in the following ways:

- Encourage schools to provide physical education programs that teach the importance of, and the skills necessary for, developing and maintaining physically active lifestyles.
- Promote changes in organizational practices within work sites and civic and recreational settings that promote active lifestyle.
- Encourage their communities to make facilities for physical exercise available to the public.
- Promote the engineering of environments which allow purposeful physical activities such as climbing stairs instead of using an elevator or escalator.
- Prescribe physical activity programs commensurate with those recommended by the CDC and the ACSM being 30 minutes or more of moderate-intensity physical activity such as brisk walking on most, and preferably all days of the week[15].

Recommendations for medical education

- The importance of physical activity for health and the use of exercise training in managing selected disease conditions should be incorporated into the education of physicians and other medical professionals.
- A physical activity history should be taken by physicians during the process of history taking

Recommendations to patients

- Patients should be taught the importance of physical activity as adjunctive therapy for medical conditions such as hypertension, type 2 diabetes, dyslipidemia and obesity.
- Health professionals should prescribe physical activity programs commensurate with those recommended by the CDC and the ACSM being 30 minutes or more of moderate-intensity physical activity such as brisk walking on most, and preferably all days of the week[15].
- Patients should be encouraged to engage in a variety of physical activities and to progressively increase their activity as tolerated.
- Health care professionals should provide an exercise prescription to patients and should familiarize themselves with behavioural change material available from the Provider-Based Assessment and Counselling for Exercise Program (PACE)[49] and the Activity Counselling Trial (ACT)[50].
- Selected exercise testing should be performed at the discretion of the physician before vigorous exercise in patients with known cardiovascular disease.

X. Areas For Future Research

Multiple aspects of physical activity and health warrant additional investigation and research:

- Research into behavioural strategies and techniques to increase physical activity levels among children and adolescents and to maintain increased activity over their life spans.
- Research into factors influencing the adoption and maintenance of physical activities in adults.
- Research into the development of strategies to improve compliance to physical exercise amongst the public and patient groups.
- Additional studies on the risks of exercise because the benefits for patients with diagnosed or occult CAD can be maximized only if the risks are as low as possible.
- Cost-effectiveness studies are needed to evaluate the role of physical activity relative to other interventions on health care costs.

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