Health Promotion

Aerobic or Resistance Exercise for maximum Cardiovascular Disease Protection? An Appraisal of the Current Level of Evidence

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Keywords

Muscle stretching exercise • Exercise • Muscle • Skeleton • Health promotion • Cardiovascular disease

Summary

Introduction. *The beneficial role of physical activity on the cardiovascular system has been well established and appreciated. The aim of this narrative review was to present a summary of the latest recommendations for physical activity, and to evaluate the most recent scientific evidence regarding the role of aerobic and or resistance exercise in relation to atherosclerotic cardiovascular disease (ASCVD) risk.*
Methods. *Narrative review; searches were performed in PubMed, Scopus and Google Scholar. The guidelines of major Organizations (i.e., European Society of Cardiology, American College of Cardiology/ American Heart Association, American College of Sports Medicine, and World Heart Federation, World Heart Organization) were also retrieved and presented here.*
Results. *Engagement in regular aerobic exercise is strongly recommended for all people and by all scientific organizations for reducing ASCVD mortality and morbidity. Resistance exercise should be implemented in addition to aerobic, however, its individual effects on ASCVD risk are not well established.*
Conclusions. *A reduction of sedentary behavior at population level reduces the healthcare costs by multiple ways. Effective approaches should be implemented that include behavior theory-based interventions, e.g., goal-setting, re-evaluation of goals, self-monitoring, and feedback. Most important is to encourage activity that individuals enjoy and/or can be included in their daily life.*

Introduction

Leisure time physical activity refers to any bodily movement that results in energy expenditure. This includes a wide range of activities, such as walking, running, dancing, swimming, gardening, *etc*. Physical activity can be structured (like organized sports or exercise routines) or unstructured (like outdoor activities). It is typically categorized into four types: aerobic activities (*e.g.*, jogging, cycling), muscle-strengthening activities (*e.g.,* weightlifting), flexibility activities (*e.g*., stretching, yoga) and balance activities. The beneficial role of physical activity on the cardiovascular system has been well established and appreciated [1, 2]. A series of studies since the 1990s have revealed that in both men and women high levels of leisure time aerobic physical activity reduces the risk of atherosclerotic cardiovascular disease (ASCVD) in a range of about 20 to 30%, compared to the risk of those with low levels of physical activity, while even moderate physical activity was significantly associated with up to 20% reduction of the ASCVD risk, indicating an dose-response relationship [3-6]. These effects were independent of the impact of physical activity on other major cardiovascular risk factors, like hypertension, diabetes, obesity, and dyslipidemia.

These accumulative lines of evidence have been summarized in a number of systematic reviews and meta-analyses. For example, a large-scale meta-analysis from the Global Burden of Diseases project, that evaluated 174 studies from all over the world, reported that higher levels of physical activity were significantly associated with 25% lower risk of ischemic heart disease and 26% lower risk for ischemic stroke. In another meta-analysis that explored the mechanistic effects of physical activity on cardiovascular system and included 57 randomized controlled trials of aerobic exercise intervention of at least moderate intensity, aerobic exercise intervention significantly raised antiatherogenic apolipoproteins and lipoprotein sub-fractions, lowered atherogenic apolipoproteins and lipoprotein sub-fractions and improved atherogenic lipid ratios. [5] A more recent meta-analysis of 148 randomized clinical trials and 36 prospective cohort studies, enhanced previous findings, reporting a 34% increased risk for ASCVD in the population with sedentary behavior, but a 29% ASCVD risk reduction in those who performed long-term physical activity as compared to the sedentary [6].

Despite extensive evidence on the impact of physical activity on cardiovascular health, the question of whether resistance exercise, either as a complement to or replacement for aerobic exercise, can offer similar or even greater protection against ASCVD risk remains a concern. Few studies have explored this relationship, and even fewer reviews have summarized and discussed the findings. Thus, the aim of this narrative review was to present a summary of the latest recommendations for physical activity, and to evaluate the most recent scientific evidence regarding the role of aerobic and or resistance exercise in relation to ASCVD risk.

Methods

Literature search

Although this is a narrative review, the basic principles of systematic reviews were followed, according to the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines [7].

A comprehensive literature search of the MEDLINE (via PubMed), Scopus and Google Scholar databases was carried out, until November 30, 2023. The literature search was performed independently by the authors. Boolean operators (*i.e.*, AND, OR, NOT) were used to make the search specific. The search string included the following keywords, according to MeSH (Medical Subjects Headings): "Physical Activity", "Diet", "Exercise", "Aerobic", "Resistance", "Anaerobic", "Cardiovascular Disease", "Heart", "Risk", "Health". The sensitivity of the search was also verified by back referencing the collected systematic reviews, meta-analysis, and independent studies. A hierarchical approach, *i.e.*, screening the title, abstract followed by the full-text manuscript, was used to search for studies. During the time-limit, references of systematic reviews and meta-analyses on the associations of physical activity and ASCVD risk were also manually searched and included. Duplicates were removed. After further screening, epidemiological studies, randomized controlled trials, and meta-analyses evaluating the independent role of physical activity on ASCVD risk, published the past 10 years, were retrieved, and discussed here.

Moreover, the guidelines of major Organizations (*i.e.*, European Society of Cardiology, American College of Cardiology/ American Heart Association, American College of Sports Medicine, and World Heart Federation, World Heart Organization) were also retrieved and presented here.

Measurement of the intensity of physical activity

At this point it should be noted that in the majority of retrieved studies and recommendations, intensity of physical activities is centered around the rates of energy that is consumed during different activities. These rates are known as Metabolic Equivalent Tasks (METs); one MET is defined as the amount of oxygen consumed while at rest, which is approximately 3.5 milliliters of oxygen per kilogram of body weight per minute (3.5 mL O_2/kg/min). Light-intensity physical activity is considered for activities less than 3 MET, moderate-intensity for activities between 3-6 MET and vigorous-intensity for activities of 7 or more MET [8].

Results

Recommendations by the European Society of Cardiology, American College of Cardiology/American Heart Association

Based on the existing large body of evidence, the latest European Society of Cardiology (ESC) Guidelines (2021) strongly recommend that all adults should be engaged in regular physical activities to reduce all-cause mortality, as well as ASCVD-specific mortality, and morbidity [9]. In particular, it is strongly recommended (Class I, Level A) that adults of all ages should strive for at least 150-300 min a week of moderate-intensity (*i.e.*, 3-6 MET) or 75-150 min a week of vigorous-intensity (*i.e.*, 7 or more MET) aerobic physical activity, or an equivalent combination thereof. It is also recommended that people who cannot achieve at least the lowest levels of physical activity, should stay as active as their abilities and health condition allow and try to reduce sedentary time throughout the day. For older adults or individuals with chronic conditions who cannot achieve 150 min of moderate-intensity physical activity a week, they should be as active as their abilities and health conditions allow. Moreover, performing resistance exercise, in addition to aerobic activity, is recommended on 2 or more days per week to reduce ASCVD as well as all-cause mortality (Class I, Level B). The suggestion is one to three sets of 8-12 repetitions at the intensity of 60-80% of the individual's maximum strength, at a frequency of at least 2 days a week in a variety of different exercises involving each major muscle group. For older adults or deconditioned individuals, it is suggested to start with one set of 10-15 repetitions at 40%-50% of their maximum strength [9].

The 2019 Joint Guidelines by the American College of Cardiology/ American Heart Association regarding physical activity also strongly recommend that all adults should be routinely counseled in healthcare visits to optimize a physically active lifestyle (Class I, Level B). In particular, aerobic exercise for 150 min per week of moderate intensity or 75 min per week for vigorous intensity (or an equivalent combination of moderate and vigorous activity) is strongly recommended to reduce ASCVD risk (Class I, Level B). For individuals unable to meet the minimum physical activity recommendations, engaging in at least moderate physical activity even in less than the recommended amount can be beneficial in reducing ASCVD risk (Class IIa, Level B). In addition, American College of Cardiology/ American Heart Association also recommend that decreasing sedentary behavior may be reasonable to reduce ASCVD risk (Class IIb, Level C).

Regarding resistance physical activity, the American College of Cardiology/ American Heart Association recommend that 90-150 minutes per week to 50%-80% of maximum intensity, of 6 exercises and 10 repetitions per set may significantly reduce blood pressure levels, but there is no mention about ASCVD risk [10].

Recommendations by the American College of Sports Medicine, and US Centers for Disease Control

In line with the ESC guidelines, the American College of Sports Medicine (ACSM) also recommends that adults should engage in, at least moderate-intensity aerobic exercise training, and resistance exercises for about 2 to 3 times per week. [11] In particular, ACSM recommends

engaging in moderate-intensity cardiorespiratory exercise training for at least 30 min per day, for at least 5 days per week (*i.e.*, ≥150 min per week) or vigorous-intensity cardiorespiratory exercise training for at least 25 min per day and a minimum of 3 days per week (*i.e.*, ≥75 min per week), or a combination of moderate- and vigorous-intensity exercise, to achieve a significant cardiovascular protection. These recommendations lead to a total energy expenditure of 500-1000 MET/min per week. In addition, ACSM also recommends that adults should perform resistance exercises in addition to the aerobic exercise, for each of the major muscle groups, and neuromotor exercise involving balance, agility, and coordination, for about 2 to 3 times per week [11]. Improvements in physical condition can be reached with any activity that uses large muscle groups, which can be maintained continuously, and is rhythmical and aerobic in nature, *e.g.*, walking-hiking, running-jogging, cycling-bicycling, cross-country skiing, aerobic dance/group exercise, rope skipping, rowing, stair climbing, swimming, skating, and various endurance game activities, or some combination thereof [11].

The latest guidelines for physical activity by the US Centers for Diseases and Prevention (US CDC) suggest a minimum of 150 minutes of moderate-intensity continuous training (MICT), or 75 minutes of vigorous exercise, or a combination of both to achieve various health benefits per week. An alternative to MICT is high intensity interval training (HIIT), defined as repeated, brief, and intense exercise bouts separated by active recovery. It is noted that HIIT produce a significant surge in VO2max and fat oxidation, improving exercise capacity and reducing health risks [12].

The Position of the World Health Organization

The World Health Organization (WHO) strongly recommends engaging in physical activities for people of all ages. Towards the physical activity recommendations made by the scientific societies, WHO has developed the 2018-2030 *Action Plan For More Active People For A Healthier World* [13]. In this Action Plan WHO considers physical activity as a very important lifestyle behavior across all ages, that can and should be integrated into the settings in which people live, work and play. Walking and cycling are key means of transportation and enable engagement in regular physical activity on a daily basis. Also, active play and recreation is important for early childhood as well as for healthy growth and development in children and adolescents. However, there is no specific distinction between the types of physical activity people should follow.

Moreover, WHO supports that quality physical education and supportive school environments can also provide physical and health literacy for long-lasting healthy, active lifestyles.

Epidemiological studies, randomized controlled trials, and meta-analyses on aerobic versus resistance exercise and ASCVD prevention.

Despite the large body of evidence regarding the effects of physical activity on ASCVD risk, there are few epidemiological studies and randomized controlled trials (RCT), and consequently meta-analyses that have evaluated aerobic versus resistance exercise and ASCVD development or even cardiovascular risk markers.

In a recent meta-analysis Momma et al. evaluated 16 prospective cohort studies that examined the association between muscle-strengthening activities and health outcomes in adults. It reported J-shaped associations with the maximum risk reduction (approximately 10-20%) at 30-60 min/week of muscle-strengthening activities for ASCVD, and all-cause mortality, whereas an L-shaped association showing a significant risk reduction at up to 60 min/week of muscle-strengthening activities was observed for diabetes [14].

In a narrative review Giovannucci et al. [15] summarized the existing evidence from cohort studies on muscle strengthening activities and risk of major chronic diseases, including ASCVD and mortality. It was concluded that engagement in muscle-strengthening activities over 60-150 min per week was associated with reduced risk of ASCVD by approximately 20%-25% reduction, type 2 diabetes by approximately 30%, as well as all-cause mortality by approximately 20-25%.

However, it should be underlined that some studies suggest that higher levels of muscle-strengthening activities (*i.e.,* more than 2.5 h/week) may have less benefit or are even harmful, for ASCVD and all-cause mortality, relative to lower levels of activity [16].

In a current systematic review and meta-analysis Khalafi et al. [17] investigated the effects of a combination of aerobic and resistance training which is described as concurrent training of aerobic and resistance versus aerobic or resistance only, on $VO_{2max/peak}$ and muscular strength, in middle-aged and older adults. They revealed that concurrent training is effective for increasing muscular strength and cardiorespiratory fitness in older adults and does not negatively affect these outcomes as compared to either resistance or aerobic alone. It was also concluded that concurrent training can be effective when aerobic and resistamce are performed during the same sessions or as separate sessions and following medium-term and long-term interventions.

The effect of progressive resistance training (PRT) on aerobic fitness and strength in adults with coronary heart disease was evaluated by Hollings et al. [18]. They investigate in a systematic review and meta-analysis 34 studies and 1,940 participants if Progressive Resistance Training was more effective compared to control, aerobic fitness, and when combined with aerobic training. They found that aerobic fitness was improved similarly after PRT (16.9%) or AT (21.0%) and that combined training resulted in a significant greater improvement in peak work compared to AT (5%). It was concluded that progressive resistance training provides improvements in

cardiorespiratory fitness that are comparable to aerobic training in adults with coronary heart disease [18].

The benefits of combination aerobic and resistance exercise on CVD predisposing factors in individuals with elevated risk was investigated by Schroeder et al. [19]. They compared the effect of 60 min/session aerobic exercise vs 60 min/session resistance training vs 30 min aerobic plus 30 min resistance / session in an 8-week exercise with 3 days/week and equal exercise time in all groups. They found that only in combined training, individuals had significant reductions in blood pressure alongside with increases in cardiorespiratory fitness, body strength, lean body mass. It was concluded that among individuals at an increased risk for CVD, as little as 8-weeks of combined training may provide more comprehensive CVD benefits compared to time-matched aerobic or resistance training alone [19].

The combination of aerobic and inspiratory muscle training versus aerobic training was investigated in patients with chronic heart failure by Adamopoulos et al. [20]. They use the multicenter randomized trial (*i.e.*, Vent-HeFT) which was designed to investigate the potential additive benefits of inspiratory muscle training on aerobic training. The study demonstrated that inspiratory muscle training combined with aerobic training provides additional benefits in functional and serum biomarkers (*i.e.*, respiratory muscle function, dyspnea, quality of life, inflammatory and cardiac) in patients with moderate chronic heart failure. Inspiratory muscle training may strengthens the diaphragm and other respiratory muscles, leading to better lung function and reduced respiratory effort during exercise, enhance oxygen exchange and delivery to the working muscles, which, when combined with aerobic training, leads to better overall exercise performance and endurance, reduce circulating inflammatory markers such as C-reactive protein and cytokines, which are often elevated in chronic heart failure, and reduce the workload on the heart by improving breathing efficiency [20].

At this point it should be highlighted that although endurance exercise offers numerous cardiovascular benefits, patients suffering from ASCVD need to approach it with caution. The increased myocardial stress, potential for ischemic damage, and other factors like electrolyte imbalances can increase their risk for developing arrhythmic events. Careful management, including regular cardiac evaluations, may be necessary to balance the benefits and risks of such intense physical activity [21].

In a systematic review Tambalis et al. [22] investigated the effectiveness of different intensities (moderate and high) of aerobic training as well as the type of exercise (aerobic, resistance, and combined aerobic with resistance) in altering the blood lipids levels of 3,042 participants from the general population (*i.e.*, the ATTICA Study). High-intensity exercise (*i.e.*, 7 or more MET) resulted in improvements in high-density lipoprotein cholesterol but for resistance and combined exercise the results were inconsistent. The heterogeneity between the types of exercise did not allow reliable comparisons, (*i.e.*, aerobic activities, muscle-strengthening activities, flexibility activities and balance activities, in terms of their physiological mechanisms to the human body) [22].

Discussion

In this narrative review we explored the latest recommendations for physical activity and evaluated a selection of the most recent, high-quality scientific evidence, including the recommendations of major health societies, regarding the role of aerobic and or resistance exercise in relation to ASCVD risk. It was confirmed that aerobic exercise is a major cardioprotective lifestyle mean for ASCVD risk reduction that should be recommended to people of all ages. Recent evidence suggests that resistance exercise on the top of aerobic, may further confer to ASCVD risk reduction. However, the effect of only resistance exercise on ASCVD risk is not well understood and appreciated [24].

There are various types of physical activities, with a significant variation in terms of their physiological effects. Aerobic training, the most well-studied type of physical activity and the one most commonly performed, enhances heart and lung function, promotes fat metabolism, and improves overall stamina. Resistance training primarily improves muscular strength and bone density. Balance training activities emphasize flexibility, balance, and coordination, and are particularly important for improving range of motion, reducing injury risk, and enhancing overall functional movement, especially among older adults. High-Intensity Interval Training (HIIT) combines short bursts of intense exercise with periods of rest or low-intensity recovery, can be applied to both aerobic and resistance training and is known for improving both cardiovascular fitness and muscular endurance in a time-efficient manner. Inspiratory muscle training is aimed at strengthening the respiratory muscles, particularly the diaphragm, and it is beneficial for people with conditions like chronic obstructive pulmonary disease (COPD) or heart failure, as it improves breathing efficiency and reduces breathlessness. Heterogeneity in exercise training is crucial for optimizing fitness outcomes and tailoring programs to individual needs [2, 8, 9].

The role of aerobic exercise on the cardiovascular system has been extensively studied. The evidence strongly suggests that aerobic exercise of at least 150 minutes per week reduces blood lipids levels, *i.e.*, total cholesterol, low-density lipoprotein (LDL) cholesterol, as well as triglycerides, and increases high-density lipoprotein (HDL) levels [9, 25]. Moreover, regular aerobic exercise helps in arterial blood pressure reduction in people with hypertension, as well as in blood pressure control and management [9, 26]. Health benefits occurred even at low levels of physical activity; for example, individuals with a total activity level of 600 MET minutes/week (the minimum recommended level) had a 2% lower risk of ASCVD compared with those reporting no physical activity, whereas an increase up to 3600 MET minutes/week the risk was reduced by an additional 19% [4].

Obesity is a major threat for developing ASCVD and diabetes [27]. Aerobic exercise has consistently shown that its importance in body weight control, and reduction in lipid accumulation, and therefore reduction of ASCVD risk [25]. However, energy balance and diet are also of crucial importance for ASCVD, thus, adherence to a healthy dietary pattern should always be recommended together with exercise [10, 29-31].

There are relatively few studies that have shown benefits of engagement in resistance exercise for the reduction of surrogate risk markers for ASCVD. The suggested recommendation by ESC and other major organizations for resistance exercise is one to three sets of 8-12 repetitions at the intensity of 60-80% of the individual's 1 repetition maximum at a frequency of at least 2 days a week in a variety of 8-10 different exercises involving each major muscle group [9]. The mechanisms that resistance exercise affects ASCVD risk have not well studied. Some interventional and experimental studies have shown that resistance exercise, such as weightlifting or bodyweight exercises, increase energy expenditure, improve muscle mass and metabolism, by increasing metabolic rate, which, accordingly, assists in weight management and reduces the risk of obesity, a significant risk factor for CVD. Resistance exercise has also been associated with blood pressure regulation [32]. Regular resistance training can help lower blood pressure by improving blood vessel function and reducing arterial stiffness. Lower blood pressure decreases the workload on the heart and reduces the risk of hypertension [33]. Moreover, several clinical trials have shown that engagement in resistance exercise has improved individuals' lipid profile, by increasing levels of HDL-cholesterol and reducing levels of LDL-cholesterol and triglycerides. Resistance training has also shown that increases insulin sensitivity, allowing cells to better respond to insulin and regulate blood sugar, as well as decreases levels of inflammatory markers, which are strongly associated with the development and progression of ASCVD, as summarized in a review paper by Westcott [34]. There are also few studies that have shown that resistance exercise improves endothelial function [35-37]. However, a significant pressure load imposed on the heart during resistance exercise, may lead to a mild form of cardiac hypertrophy. In addition, a marked rise in blood pressure is secondary to resistance exercise; thus, a high-level resistance may have adverse effect on those with uncontrolled hypertension [37]. Thus, incorporating moderate-level resistance exercise into a well-rounded fitness routine, can significantly reduce the risk of ASCVD and improve overall heart health.

In conclusion, engagement in regular physical activity by adults of all ages for reducing ASCVD mortality and morbidity is strongly recommended by all scientific organizations. Furthermore, the latest ESC Guidelines for ASCVD prevention extend beyond standard recommendations, advising that physical activity should be tailored to the individual and prescribed (as pharmaceutical medication) based on frequency, intensity, duration, type (such as aerobic and/or resistance training), and progression. A reduction of sedentary behavior at population level reduces the healthcare costs by multiple ways. To achieve this, effective approaches should be implemented that include behavior theory-based interventions, *e.g.*, goal setting, re-evaluation of goals, self-monitoring, and feedback. Under this perspective, the important role of healthy diet should never be disregarded or underestimated. The most important factor is to encourage activity that individuals enjoy and/or can included in their daily life.

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Conflicts of interest statement

None.

Authors' contributions

ND: performed literature search and wrote the paper; DP: critically reviewed the paper and evaluated the retrieved studies.

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