

The Connection Between Chronic Illness and Physical Activity

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Abstract: *Chronic diseases have become a focal point of public health worldwide with estimates of trillions of dollars in annual health care cost and causing more than 36 million deaths a year. Lifestyle factors such as physical inactivity are heavily correlated with the development of many chronic diseases. New strategies for primary and secondary disease prevention are desperately needed to aid in blunting the negative economic and social impact of these diseases. Physical activity (PA) and exercise are now considered principal interventions for use in primary and secondary prevention of chronic diseases. Currently, more emphasis in primary prevention of disease is necessary to reduce disease risk in youth and adults; however with chronic disease prevalence so high, similar emphasis is also necessary for secondary prevention in those children and adults already inflicted with chronic diseases. Conditions such as cardiovascular disease, type 2 diabetes, obesity, and cancer are drastically improved when PA and exercise are part of a medical management plan. In addition, the national PA guidelines in conjunction with PA promotion tools like Exercise is Medicine™ are needed to promote increased PA and exercise levels worldwide.*

Keywords: Chronic disease; Physical activity; Primary prevention; Secondary prevention

I. INTRODUCTION

Currently, five babies are born per second in the world, and these children can anticipate living longer than previous generations with a life expectancy of more than 69 years¹ which is approximately 6 years longer than the life expectancy of a mere 20 years ago.¹ Even though children are expected to live longer, the quality of their lives is increasingly threatened by disease. Presently, chronic disease is the number one cause of death. In the past century a dramatic shift from no industrialized countries suffering from communicable diseases to industrialized/modernized countries burdened with chronic diseases has taken place. This shift continues in many areas of the world including some of the most heavily populated countries. The increase in chronic disease rates has created an enormous social, emotional, and economic burden that prevails throughout the world.

Physical Activity (PA) and Disease Prevention

The most prevalent chronic diseases are cardiovascular disease (CVD), cancer, type 2 diabetes, various respiratory diseases, and osteoarthritis. These diseases are burdensome, debilitating and potentially lethal to individuals inflicted, and while debilitating, medical treatment and annual health care costs continue to rise into trillions of dollars each year. In the past, these diseases were associated with older populations, however because of lifestyle shifts, chronic diseases are now becoming more prominent in younger adults leaving them burdened and encumbered with health care concerns for the rest of their lives. One lifestyle shift that has been identified as being in part responsible for the earlier onset of chronic disease is the prevalence of physical inactivity. PA and exercise are considered a principal intervention for primary and secondary disease prevention. Nonetheless, physical inactivity is escalating in all age groups around the world, especially adolescents. A recent investigation conducted in the U.S. found that 77% of surveyed children under the age of 13 had not performed any vigorous PA in the past 7 days while only a meager 15% met the recommended 60 min of PA per day. With this information in mind, incorporating PA and exercise in everyday living is essential for primary disease prevention.

Lifestyle factors such as physical inactivity are heavily correlated with the development of chronic disease. This relationship is supported by epidemiologic studies completed over the past century. Even though physical inactivity is

not the only lifestyle factor associated with the development of chronic disease, this factor in recent years has received much interest. Initial investigations examining the relationship between PA and chronic disease development were performed in 1953 by Morris et al., who examined CVD risk in London's double-decker bus conductors and drivers. He found that the more active conductors were less likely to suffer from CVD than the inactive drivers. This work was ground-breaking and was the first major analysis showing long-term health benefits associated with PA and exercise. As Morris was publishing this work, Paffenbarger et al., were developing a similar investigation concerning California longshoremen. His research team investigated 6351 longshoremen ages who were classified by job description which was based on PA level. Similar to the results of Morris, the more physically active longshoremen were found to have lower all-cause mortality rates. Some 33 years after the initial Morris study, the relationship was again depicted when Paffenbarger et al. released the Harvard alumni study. In this long term investigation, Paffenbarger et al. followed 19,936 Harvard alumni, aged for 16 years (1962e1978) and reported 1413 alumni whose primary cause of death was from chronic disease. However, all-cause mortality was better for individuals having higher PA levels. Three years later Blair et al. released another landmark study linking PA to all-cause mortality. This study followed 13,344 patients receiving preventive medical examinations at the Cooper Clinic in Dallas, Texas from 1970 to 1981. Mortality rate for these patients was significantly correlated with the amount of PA completed. These pioneering studies showcase the importance of being physically active and the potential life-threatening effects of physical inactivity.

These monumental studies initiated an increased awareness for the need to become physically active for the purpose of developing and maintaining good health. In 1995, Pate et al. summarized the importance of PA in a position statement with the Center for Disease Control and Prevention and the American College of Sports Medicine (ACSM). A primary objective of these recommendations was to encourage increased PA participation among Americans of all ages. The issuing of these public health recommendations regarding the types and amount of PA and exercise needed for good health and disease prevention represent the first evidence-based guidelines for PA and exercise in the U.S. Some 4 years later in 1999, Australia released the first ever national PA guide- lines. These guidelines were followed in 2008 when the National PA Guidelines for the U.S. were released. In the last decade other countries have drafted guidelines for PA including Canada, UK, Ireland, Austria, Finland, Brazil, Japan, Sweden, and China.

The importance of PA and exercise in regards to improving health has slowly been propagated throughout the world, however even with this increased awareness, the world levels of PA over the past decade have remained unchanged and in a few settings even decreased. Some areas in the world have recorded sedentary behavior (any PA that has an energy requirement of less than 1.5 METs) levels greater than 50% recording the worse levels. Data reported from the National Health and Nutrition Examination Survey (NHANES) cohort indicate that on the average children and adults spend more than 55% of their awaking hours as sedentary. Similar results are reported for Australian adults who spend 57% of their day as sedentary. Even countries that are typically thought of as more physically active are now reported as having higher levels of sedentary behavior. However, caution is needed when comparing values of sedentary behavior between studies. Early studies used self-reporting as the primary method for measuring PA, but over time PA studies using accelerometer methodology have gained prominence. This change in data collection methods (e.g., accelerometer vs. self-report) can likely create PA differences that do not reflect behavior change. To truly compare results from any type of activity study, the research designs considered must receive careful analysis to ensure that similar data collection methods are used. Nonetheless, evidence is readily available to support that a lifetime of physical inactivity provides physiological disadvantages that ultimately leads to poor health and increases the likelihood for the early onset of chronic disease.

As previously noted, chronic diseases are now the leading cause of death in the world and account for 63% of all deaths in the year 2010. Both epidemiological and longitudinal intervention evidence fully support the use of PA and exercise in the primary prevention of chronic disease. Though many countries are presently advocating for increased exercise and PA, these actions unfortunately have yet resulted in dramatic change. A more concerted effort involving all levels of the ecological and social framework is needed to fully embrace PA change.

Nevertheless, as PA and exercise provide many primary prevention health benefits, PA and exercise also provide similar benefits in secondary disease prevention. When PA and exercise are initiated after a chronic disease is diagnosed, many of the harmful disease effects are ameliorated and in some cases (e.g., type 2 diabetes) the disease progression is slowed or halted. PA and exercise when used as part of the medical management plan for secondary

disease prevention will almost always improve the quality of life and potentially extend the life of a disease individual. In this regard, the benefits of PA and exercise depend on the type, severity, and comorbidities of the disease.

Disease and Loss of Functional Capacity

The detrimental physiological effects of physical inactivity and sedentary behavior on health and physical functioning are well established. Individuals with a chronic disease are likely to become less physically active which in turn leads to a cycle of deconditioning. The result of this downward cycle is a loss of functional capacity and subsequent further reductions in the ability to perform PA and exercise. In order to stop this downward cycle and increase functional capacity, individuals with a chronic disease should receive information and/or counseling regarding the safety, effectiveness, and proper use of PA and exercise prescription. If this cycle of deconditioning is not stopped, the consequences for poor long term health and suboptimal quality of life are greatly increased.

In the last several decades much attention has been directed toward primary and secondary disease prevention by developing the role of PA and exercise to improve health and physical fitness. From a secondary perspective, the initial goals for increasing PA and exercise are to reverse the physical deconditioning resulting from physical inactivity and/or sedentary behavior, optimize physical functioning, and enhance overall health and well-being. Weiler et al. recently wrote that various professional bodies now recognize the existing large evidence base showing the potential for cost-effectiveness and the significance of promoting PA for primary prevention and secondary disease treatment. He reviewed 39 different national PA guidelines and found that each contained PA promotion features. He suggests that if a patient's medical management plan for any disease where PA and exercise are known to be beneficial does not contain PA and exercise recommendations or does not provide advice regarding appropriately PA, a strong possibility exists that medical negligence has occurred.

Within any disease or medical condition, a wide range of physical abilities and varied ways for individuals to respond to PA and exercise exist. This diversity in physical abilities and PA responses are largely determined by one or more of the following: the severity and/or progression of the disease or medical condition, the response to treatments, and the presence of other comorbidities. Consequently, the specific health outcomes for PA and exercise programming are not always known, but may range from arresting or attenuating the deterioration in functional capacity to markedly improving physical and health status.

PA, Exercise, and Disease Prevention

For many diseases expected health benefits resulting from increased PA and exercise are not always known. Presently, a move toward active support from the medical community in recommending a medical management plan that includes PA and exercise programming and routine referral to exercise professionals is critical. Trained professionals can provide counseling that will facilitate change and optimize the use of intervention strategies to promote primary and secondary disease prevention. Such increased interest, support, and encouragement from the medical management team as well as developing a better understanding in how to design PA and exercise programs tailored to each individual's needs are positive steps toward optimizing and obtaining goals for improved physical functioning, health, and well-being. The remainder of this review is dedicated toward describing the benefits of establishing PA and exercise as secondary prevention for specific chronic diseases including, CVD, type 2 diabetes, obesity, and cancer. Many diseases such as osteoarthritis are not reviewed. However, even though many health conditions such as osteoarthritis and others are prominent chronic diseases that are potentially debilitating and severely limiting, a discussion of these diseases is beyond the scope of this review. For more information on osteoarthritis or other diseases and secondary prevention, the reader is encouraged to review some references.

Cardiovascular Disease

CVD is the most common chronic disease around the world . Approximately one-half of chronic disease deaths in 2010 were credited to CVD. The term cardiovascular disease includes coronary heart disease, cerebrovascular disease, peripheral arterial disease, rheumatic heart disease, congenital heart disease, deep vein thrombosis, and pulmonary embolism among others. With the exception of genetic cardiovascular disease, a high correlation exists among CVD and physical inactivity. This correlation was established over the course of several decades by epidemiologic studies

designed to determine factors associated with CVD risk. These factors are characteristics that when present increase the possibility of being afflicted with disease. Numerous risk factors are identified for CVD and are divided into modifiable and non-modifiable risk factors. Modifiable risk factors include elevated blood pressure, elevated blood cholesterol, elevated blood glucose levels, cigarette smoking, and obesity. Once PA, dietary, and smoking cessation interventions are addressed, the clinical manifestations are reduced. By knowing whether an individual has one or more of these factors, their CVD risk or risk stratification (low risk, moderate risk, or high risk) as outlined by the ACSM or the American Heart Association (AHA) is established. Risk stratification enhances the practitioner's ability to understand a patient's disease state and gives insight into potential disease progression. Once risk stratification is completed, the appropriate lifestyle modification interventions are identified and incorporated into a tailored medical management plan to reduce the risk of future cardiac events. The practitioner meets with the patient, reviews the plan, and gives counsel regarding various parts of the plan including lifestyle intervention.

Currently, the number of individuals around the world with CVD embodies the need for PA and exercise as a lifestyle intervention. Daily PA and exercise reduce CVD risk as well as signs and symptoms while increasing functional capacity. The 1995 guidelines produced by the Agency for Health Care Policy and Research (AHCPR)⁵¹ report that cardiovascular mortality is reduced in myocardial infarction patients who participate in secondary disease prevention such as comprehensive cardiac rehabilitation programming that includes PA and exercise. For all CVD, the quality of life is increased when medical programming includes PA and exercise training. Generally, individuals with CVD who become physically active realize multiple benefits⁵³ including an improved functional capacity, improved muscular strength (when strength training is part of the rehabilitation program), reduction in submaximal heart rate, reduced blood pressure, reduced rate pressure product, reduced inflammatory markers, relief of angina symptoms, possible decreases in body weight, and increases in high density lipoprotein cholesterol (HDL-C). Myocardial infarction patients enrolled into a 36-month cardiac rehabilitation program typically experience an 11% to 36% increase in aerobic or functional capacity. This large range of values is due to variation in initial fitness level and the amount of PA and exercise completed. Increases in functional capacity provide for improving the ease to perform daily activities. The mechanism for this improvement is associated with the reduction in the amount of myocardial ischemia brought on by increased functional capacity.⁵⁸

Individuals diagnosed with CVD or having suffered a myocardial event should also receive educational information and counseling about the disease process and lifestyle intervention strategies in order to reduce the likelihood for further incidents. The 2008 PA Guidelines state that moderate PA is safe for almost everyone including those with chronic diseases. Although these guidelines do not provide a specific prescription for CVD individuals, they do point out that more health benefits are seen when the exercise volume or dose is increased from 150 min to 300 min a week. Other existing position statements and guidelines support this stance such as the Swedish PA in the Prevention and Treatment of Disease Guidelines. These Swedish guidelines give specific prescriptions for different manifestations of CVD. Other position statements such as the AHA/American College of Cardiology (ACC) 2006 guidelines for secondary prevention of CVD state that patients should achieve a minimum of 5 days a week of moderate intensity PA for 30 min a day. These guidelines and position statements are essential in providing information for medical management professionals on the use of PA and exercise for secondary prevention. When used correctly, PA and exercise prescriptions based off of these guidelines provide substantial health gains.⁶⁰ Haennel and Lemire reported that CVD patients benefited with significant reductions in the incidence and had improved mortality rates when 30 min a day (most days of the week) of PA was completed. Leon et al. found that exercise-based cardiac rehabilitation programs reduced total mortality by 20%, cardiac mortality by 26%, nonfatal myocardial infarctions by 21%, and the need for percutaneous transluminal coronary angioplasty (PTCA) by 19% when compared to the usual care control group. These secondary prevention disease improvements seen with PA and exercise in individuals with CVD are astounding and show that in many cases the detrimental effects of a lifetime of physical inactivity are blunted by comprehensive cardiac rehabilitation programming that includes increased PA and exercise.

Type 2 Diabetes

The incidence of diabetes mellitus is on the rise throughout the world and is vying for the most common chronic disease. This rise is mostly due to escalating cases of type 2 diabetes. Shaw et al. in 2009 reported 24 million

Americans had diabetes, a sizeable fraction of the 285 million cases worldwide. In addition, 60% of Americans not diabetic were found to be prediabetic; a condition in which blood glucose levels are well above normal. Risk estimates for Americans born after the year 2000 show that these individuals have a 33% greater chance of becoming type 2 diabetic. Usually the onset of type 2 diabetes is associated with a decrease in life expectancy and an increased risk for developing other chronic disease such as CVD, but this disease process is heavily influenced by positive lifestyle change such as increased PA and exercise, and in some cases lifestyle change improves early mortality and morbidity rates. Nonetheless, increasing physical inactivity levels are related to the rising rates of type 2 diabetes.⁶³ Presently, only 39% of type 2 diabetics reported meeting the level of PA recommended by the 2008 PA Guidelines, while 58% of healthy adults (not having type 2 diabetes) reported meeting the recommended level of PA. Because of the reported PA and exercise health benefits for type 2 diabetics, lifestyle interventions incorporating PA and exercise are important for both primary and secondary disease prevention.

A primary aim of the medical management plan for diabetics is to maintain optimal blood glucose, lipid, and blood pressure levels. When these three factors are properly maintained, abnormal physiological function returns to normal, and most symptoms and in some cases the entire diabetic disease process are ameliorated or postponed.⁶⁶ Traditionally, aerobic exercise has been a cornerstone of secondary prevention for type 2 diabetics. One week of moderate to vigorous aerobic PA or exercise can positively change overall body insulin sensitivity. Increased insulin sensitivity is directly related to an increased expression of GLUT4 receptors which subsequently will increase glucose uptake. In addition to increased insulin sensitivity, skeletal muscle proteins and enzymes associated with glucose metabolism and insulin signaling and expression are increased. Regular PA and exercise also promote fat oxidation and muscle lipid storage that results in an increased fat oxidative capacity. Furthermore, increases in PA and exercise levels are a factor in weight reduction.⁶⁸ Weight loss is associated with increases in HDL-C and significantly improves blood low-density-lipoprotein cholesterol and triglyceride levels. Lastly, PA and exercise have an important role in effecting comorbidities commonly seen with type 2 diabetes. Regular PA in most cases reduces systolic blood pressure but not in all cases while diastolic blood pressure is rarely lowered.

Type 2 diabetics are encouraged to participate in both structured and unstructured PA and exercise. Also, the 2008 Physical Activity Guidelines for Americans suggest that additional health benefits are gained by completing up to 5 h (300 min) of moderate to vigorous PA a week. Diabetics are a group of individuals that could receive these additional benefits from increased PA, and most guidelines suggest the inclusion of structured exercise programming as part of their medical management plan. Structured exercise is performed at least three times a week and preferably five or more times per week with no more than 2 days of rest between exercise sessions. This recommendation is based on the knowledge of the temporary nature of exercise-induced insulin effects. Health benefits and functional capacity improvements are best optimized with 5 days a week of regular PA and exercise. Though most diabetics gain health benefits from brisk walking at moderate exercise intensity levels, more beneficial effects are seen with higher exercise intensity levels. A recent meta-analysis found exercise intensity as the biggest determinant for blood glucose reduction in contrast to many who believe that exercise volume as the better determinant. Even so, diabetics when starting to exercise or become more physically active are often limited by a low aerobic capacity (e.g., the average type 2 diabetic has an aerobic capacity of 22.4 mL/kg/min which is well below the average adult). As a result, the duration of each exercise session can be as short as 10 min, but with multiple daily 10-min segments (30 daily total minutes is recommended). When considering diabetes, regular PA and exercise provides the greatest impact when included as part of the medical management plan. If these programs were implemented as part of primary or secondary prevention programming, global spread of this disease would be slowed.

Obesity

Although obesity is not traditionally viewed as a chronic disease, it is heavily associated with negative health implications and is often linked to several chronic diseases including CVD, certain cancers, osteoarthritis, and type 2 diabetes. The link between obesity and chronic disease is associated with obese individuals having very low levels of cardiorespiratory fitness and who are extremely physically inactive. Obesity rates are increasing throughout the world.

When the energy balance is tilted in the opposite direction, so that more calories are expended than consumed, obesity does not usually occur. Thus, lifestyles interventions incorporating PA and regular exercise are essential strategies for

primary and secondary obesity prevention. Recent investigations provide interesting data strongly supporting the notion that physical inactivity increases the risk for obesity (odds ratio 3.9, 95% confidence interval 1.4e10.9). Nonetheless, small increases in daily PA and regular exercise by the youth of today can serve as an essential approach for primary disease prevention. Still, because obesity rates are high, daily PA and regular exercise remain an important component of secondary prevention programming.

Because daily PA does aid in weight loss and ameliorates the physiologic dysfunction seen with obesity, guidelines from the National Heart, Lung, and Blood Institute encourage the use of PA and exercise to obtain a 10% weight reduction in overweight and obese individuals.⁸⁶ This recommendation is supported by the substantial evidence demonstrating that a 3%to5% reduction in body weight can substantially improve health risks. Regardless of weight loss, daily PA improves an obese individual's functional capacity and their cardiorespiratory fitness while reducing their risk for chronic disease. In 2009 a position stand released by the ACSM recommends that at least 250 min of moderate to vigorous PA be completed each week by individuals who want to lose body fat. commendation is very similar to the 2008 . PA Guide- lines recommending 300 min each week to optimizing health benefits.²⁸ While small amount of daily PA and exercise do provide health benefits, the amount of PA and exercise must be great enough to cause a negative energy balance to see reductions in body weight.

Cancer

During the past six decades, cancer prevalence has steadily increased to become the second leading cause of death in the world.⁸⁸ Nearly 15% of all deaths are attributed to cancer⁸⁸ while almost 600,000 deaths are attributed to cancer. In some countries cancer has surpassed CVD in having the highest mortality rate. the World Health Organization estimates that over 30% of cancer cases are preventable by incorporating a lifestyle that includes PA and regular exercise. Presently, several types of cancer are associated with physical inactivity while epidemiological studies report increased PA is associated with decreased risk for breast cancer, colon cancer, and prostate cancer.

Even as PA and exercise lifestyle interventions are recognized strategies for primary prevention, these same interventions improve survival rates and quality of life for individuals already suffering from disease. Thus, PA and exercise have been evaluated as a strategy in the secondary prevention for breast, colon, and prostate cancer. Most studies find improved mortality rates and quality of life when PA and exercise are incorporated into the medical management plan. Few properly designed studies are available evaluating the use of PA and exercise in secondary disease prevention for many forms of cancer. Thus, opportunities for future investigations exist in a variety of cancer areas. Regarding PA and breast cancer, Holmes et al. followed 2987 females diagnosed with breast cancer between 1984 and 1998 recording their PA levels. Women reaching at least 3 MET-h/week of PA had significantly higher survival rates relative to women achieving lower PA levels. In a similar study Holick et al. followed 4482 females diagnosed with breast cancer between 1988 and 2001 and recorded PA levels. Their data support the conclusion that women reaching a minimum of 2.8 MET-h/week of PA had significantly improved survival rates. Similar results are found for colon cancer and prostate cancer.^{96e98} Because of this information, PA and exercise must be incorporated as part of a comprehensive medical management plan. In those instances when these lifestyle interventions are included, survival rates and quality of life are greatly improved in individuals afflicted with several forms of cancer.

II. CONCLUSION

The prevalence of chronic disease throughout the world has lead scientists and health professionals to consider various means of primary disease prevention and secondary disease treatment. Throughout the discussion presented in this manuscript, the importance of PA and exercise for primary and secondary disease prevention is reviewed. This notion is an essential concept found within the ACSM initiative Exercise is Medicine™ which promotes daily PA and exercise as a part of everyday life. Because of the many associated health benefits, PA and exercise should be viewed as a medication. As is the case for many chronic diseases, the health benefits of PA and exercise surpass those of conventional medications. Beta blockers commonly used in the treatment of hypertension and other cardiovascular diseases result in resting heart rate reductions that are comparable to reductions found with regular exercise participation. Because of these health benefits, PA and exercise are now included as part of the medical management plan for many chronic diseases. One of the most notable benefits of using PA and exercise is the absence of side-

effects, as opposed to those found with classic medication use. Unlike traditional medications, PA and exercise change the underlying mechanisms for physiological functioning, whereas traditional medications mask the signs or symptoms or alter physiologic functioning in an unnatural fashion. Improvements in cardiovascular function seen with PA and exercise are excellent examples. Exercise causes increased myocardial oxygen supply,⁹⁹ decreased myocardial oxygen demand,⁹⁹ increased myocardium electrical stability,¹⁰⁰ and overall improved myocardial function.¹⁰¹ This improved myocardial function is associated with decreases in other variables such as heart rate, systolic blood pressure and blood catecholamine levels at rest and all sub-maximal exercise levels. All of these changes contribute to a better functioning cardiovascular system and improved functional capacity. Physiological change brought on by PA and exercise is not limited to the cardiovascular system. In fact, all bodily systems are functionally altered and improved by PA and exercise. The realization of the importance of daily PA and regular exercise as a strategy in primary disease prevention has led many countries to develop national PA guidelines.

Chronic diseases are the leading cause of death worldwide. Their incident rates continue to increase and this increase is heavily associated with an increase in physical inactivity.³⁵ While obvious that more emphasis in primary prevention is necessary to reduce disease risk in youth and adults, similar emphasis is also necessary for secondary disease treatment in those children and adults already inflicted with chronic diseases. PA and exercise continue to gain recognition as important lifestyle interventions for use in primary prevention and secondary prevention. Many countries have developed PA guidelines, and these guidelines in conjunction with PA promotion tools such as Exercise is Medicine™ are needed to educate health professionals on the importance of exercise in disease management. As more countries incorporate PA and exercise as part of primary and secondary prevention strategies, chronic diseases such as CVD, type 2 diabetes, stroke, cancer, and many others, along with their health care costs will be reduced while the quality of life is improved.

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