MINI-REVIEW

Physical Activity and Health

Joanna Kruk

Abstract

Physical activity is an important determinant of both physical and psychological health. Regular physical activity exerts beneficial effects on onset and progression of a number chronic diseases, well-being, and has positive effect to communities and societies. Unfortunately, more than 60% of world wide adults do not reach the recommended levels of physical activity. This paper presents the prevalence, health risks, and economic costs of physical inactivity. It also reports the substantial physical and psychological health benefits of regular physical activity.

Key Words: Physical inactivity - costs - regular physical exercise - benefits

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Introduction

Scientific evidence indicates that regular physical activity, exercise, and fitness are a key determinant of health. Appropriate dose of regular physical activity, participation in sports provides male and female of all ages, including those with disability, with physical and mental health benefits, as well as with social relationships. Physical activity is a cheap and strong means for prevention of diseases, improvement health and well-being, and it also promotes integration and social interaction (WHO, 2003). This report provides the public health recommended levels of physical activity, the prevalence and costs of physical inactivity, and the health benefits of regular activity.

Determinations of Physical Activity and Recommended Levels

Physical activity refers to all energy expended by movement, and is defined as any body movement produced by skeletal muscles that results in energy expenditure above resting level (Caspersen et al., 1985). This definition includes all types of activity: household and outdoor chores, the jobs held outside the home (occupational activity) walking, cycling, shopping, sports, intentional exercises, and other activities of daily living or other recreational activities. In turn, exercise is vigorous activity, planned, and structured, designed specifically to improve fitness and health. Examples include brisk walking, cycling, aerobic, competitive sports. Physical fitness is defined as set of attributes such as stamina, mobility, and strength that are associated with ability to perform physical activity. Fitness mainly results from levels of physical activity, although also depends on genetic factors. The effect of genetic factors is noticeable especially in competitive sports, like weight lifting or distance running. Physical inactivity is defined as a state of no marked increase in energy expenditure above resting level (EUPHIX, 2008). It responds to usual daily leisure-time energy expenditure of <1.5 kcal per kilogram per day (Warburton et al., 2007).

Physical activities performed regularly as part of a subject's daily routine (dressing, bathing, climbing, flight of stairs, walking) are called usual activities. In turn, intentional activities are those that are performed in addition to the usual activities. These activities are planned and often done at leisure time.

Complete assessment of physical activity irrespective of its type (household, occupational, recreational called also leisure-time activity, transportation-walking, bicycling for a purpose of going somewhere) must include three its components: frequency, duration and intensity (AICR, 2005). Frequency describes the number of times that the activity is undertaken in a given period (e.g. three times per week). Duration informs about the total time spent in activity during the same period (e.g. 30 min per week). Intensity describes the amount energy expenditure by a person during the activity. The intensity of physical activity is often stratified into three levels: light (<3 METs), moderate (3-6.0 METs) or vigorous (>6 METs). One MET, a metabolic equivalent of energy expenditure, is the energy expended during sitting quietly. This unit is equivalent to an oxygen uptake of 3.5 mL per kilogram of body weight per minute for an adult weighting 70 kg (Ainsworth et al., 1993). The MET value defines the ratio of the metabolic rate of an activity to the resting metabolic rate. For example, jogging (7 MET) requires 7 times higher energy as sitting quietly. Moderate – peace walking has a MET-value of about 3-4, whereas sedentary behaviours ranging from 1 to 1.5 METs. Moderate physical activities are those that require effort equivalent

Institute of Physical Education, Faculty of Natural Sciences, University of Szczecin, Szczecin, Poland Joanna.Kruk@univ.szczecin.pl

to a brisk walking (Shephard and Futher, 1997). Moderate intensity of activity increases heart rate to around 64-76% of its maximum (Warburton et al., 2007; WCRF/AICR, 2007). Moderate intensity activity burns 3.5-7 kcal/min; example activity are: dancing, leisurely bicycling, volleyball, badminton, gardening, walking and lifting during the job, e.g. farming (Kushi et al., 2006). Vigorous physical activities engage large muscle groups and cause evident increase in heart rate (77-93% maximum), breathing rates, and cause sweating (Shephard and Futher, 1997; Warburton et al., 2007; WCRF/AICR, 2007). Jogging, running, fast bicycling, swimming, singles tennis, basketball, digging, carpentry, forestry are examples of vigorous activity. Vigorous intensity activity burns more than 7 kcal/min (AICR, 2005).

Research on physical activity and health has pointed clearly that regular physical activity has important health benefits. Although the optimal dose (duration x frequency x intensity of activity) needed to be healthy remains unclear. Public health recommendations on sufficient intentional physical activity, developed by a variety of national and international organizations and agencies, have changed with evidence on dose accumulation in the epidemiologic literature (AICR, 2005; Warburton et al., 2007). The most recent recommendations for health prevention emphasizes moderate physical activity at least 30 minutes on 5 or more days of the week or a minimum 20 minutes of vigorous intensity physical activity 3 or more days per week for adults. These guidelines correspond with the Eurobarometer 2002 study of 50 MET-hours per week total moderate activity accumulated over 7 days or 25 MET-hours per week of vigorous intensity accumulated over 3 days (EUPHIX, 2008). The amount of physical activity for children and adolescents meet the recommendation at least 60 minutes of moderate intensity activity at least 5 days per week, preferably daily (American Cancer Society, 2008). It is worth noting that although much of the health gain is obtained through the above mentioned dose of activity, the dose may not be sufficient to protect against certain cancers. Therefore, the American Cancer Society updates the physical activity guidelines every 5 years. Recently the WCRF/AICR guidelines for cancer prevention recommend engage in at least 30 minutes of moderate physical activity every day. Improvement of fitness needs 60 minutes or more of moderate activity or 30 minutes or more of vigorous physical activity every day (Warburton et al., 2006a). For more details see the review of Bucksch and Schlicht, 2006.

Direct and Indirect Costs of Physical Inactivity

The importance of participation in physical activity regularly for health and well-being is accepted by much of the general population. Nevertheless, the majority of people, especially in industrialized countries, achieve sedentary or insufficient levels of physical activity. Professor Steven Blair (2009) maintains that "physical inactivity is one of the most important public health problem of the 21st century, and may even be the most important". Direct measurements of physical activity using

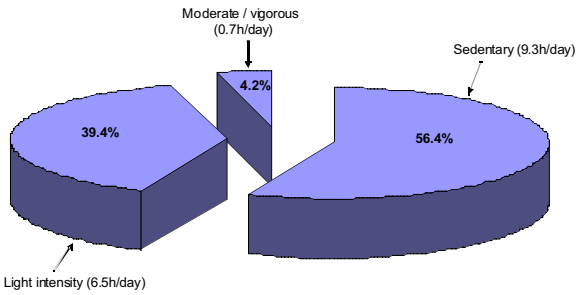

Figure 1. Percentage of Adults' Waking Hours Achieving Sedentary, Light Intensity and Moderate/ Vigorous Intensity of Physical Activity (after Owen et al., 2009)

an accelerometer technique, showed that adults, on average, spend 56.4% their awaking time in sedentary activities (Figure 1), and only 4.2% of awaking time in physical activities of moderate to vigorous intensity (Owen et al., 2009). A daily long time spent sitting (9.3 hours) may cause adverse metabolic and health effects because moderate/vigorous leisure time activity of 0.7 hours/day may be not sufficient e.g., for prevention against overweight and obesity (Warburton et al., 2006b). Therefore, reduction of sitting time should be recommended for maintaining healthy weight and the prevention of further weight gain. It should be noted that even breaks in sedentary time may be beneficial for various metabolic profiles (Healy et al., 2008).

According to a WHO report (Bull, 2006) data on levels of physical activity are known from less than one third of countries, mainly from Western Europe, North America, Australia, and New Zeland. Other countries reported data only from selected regions or not all. A review by Oldridge (2008) based on the World Health Organization data estimated that the prevalence of physical inactivity among adults at less than the levels recommended for enhancing health can range from 17% to 91% between countries. The percentage of adults achieving sedentary level of physical activity is the lowest in Australia (15%) (Medibank, 2007), and the highest in Brasil (80%) (Monteiro et al., 2003). In Europe, the percentage of people undertaken sufficient total physical activity in 2002 was the highest in Netherlands (about 44%) and the lowest in Sweden (about 23%). According to current guidelines, about 29% of the European population shows sufficient physical activity, only (EUPHIX, 2008). The WHO (2006) estimated that in the European Union at least two thirds of people aged above 15 years engage in less than 30 minutes physical activity of moderate intensity daily. In Poland the percentage of the population having the level of recreational physical activity recommended for enhancing health (30 minutes on most days) was estimated to be 38% for adult male and 34% for adult female (Drygas et al., 2008). Across the European Union Member States, in Poland, Netherlands and Lithuania the percentage of people who had "a lot of physical activity at work" in 2005 was the highest (27%) and the percentage was the lowest in Italy and Malta (10%) (EUPHIX, 2008). In 2002, 17% of the global population was classed as physically inactive and another 41% as insufficiently active for health care and well-being (WHO, 2002).

The health cost of physical inactivity (less than 2.5 hours/week physical activity of moderate intensity or 1 hour/week of vigorous intensity) appears very high (Table 1). In 2002, the World Health Organization listed physical inactivity as one of 10 powerful risk factors for premature death. The organization concluded that 1.9 million premature deaths globally and some 600,000 in the European Region, and also 19 million disability adjusted for age could be due to insufficient physical inactivity (WHO, 2002). Coronary heart disease (CHD), stroke, type 2 diabetes, some cancers (colon, rectal, breast) and depression were specified as the causes of death. Furthermore, it is estimated that physical inactivity is a cause about 22% ischemic heart disease and 10-16% cases of each of the above mentioned type of cancer (WHO, 2003). Strong evidence exists that physically inactive people have up to double the risk of heart disease compared to active (Cavill et al., 2006). Moreover, an increase by about 9% of deaths from 2005 by 2030 due to cardiovascular and coronary heart diseases in developing countries and by 1% in developed countries are prognosed (Oldridge, 2008). In most countries in the world five determinants of lifestyle, such as physical activity, unhealthy diet, caloric excess, obesity, and smoking associated with chronic diseases are the greatest public health problem. It is worth-mentioning that physical activity, usually the highest at ages 18-29 years, declines sharply with age throughout the late adult years (Bull, 2006). For example, 63% of Australian people were sufficiently active during ages 18-24 years, and 41% those at ages 55-64 years in 2000 (Medibank, 2007). Father, many older Americans are inactive. In 2000, only 16% of Americans aged 65 to 74 participated in recommended levels of moderate activity, and 12% those aged 75 and older. Estimates for 2000 showed that the recommended 20 minutes three or more days per week of regular vigorous activity was reached by 13% of people aged 65-74 years and only 6% of those aged 75 years and older (PAOA, 2002). It is well recognized that adults with higher educational attainment are more physically active during leisure time than those less educated. Also, male adolescent and men are more active than female adolescent and women (Bull, 2006).

The prevalence of physical inactivity and poor diet are the major causes of an epidemic of overweight (body mass index, BMI ≥25 - <30 kg/m^2) and obesity (BMI ≥30 kg/m^2) that is affecting worldwide populations independent of age. This is caused by fact that a great deal of time people spend in sedentary behaviours, e.g. watching television, using computers, and using cars, buses for transportation. Weight maintenance depends on a balance between energy intake and energy expenditure. When the balance is disturbed and energy intake is higher than its expenditure throughout a certain period of time, overweight and obesity develop. It is estimated that more than one billion adults worldwide are overweight and further at least 300 millions clinically obese (WHO, 2003). For example, in the United States the prevalence of obesity increased at least by 50% during 1990-2000 (PAOA, 2002) and caused 300,000 deaths annually (WHO, 2003). The incidence of a higher rate of obesity also occurs in many countries of Latin America, the Middle East and Asia (WHO, 2003). According to the WHO (2003) estimates by 2013, 200 million people could become obese in China. In Europe, the incidence of obesity occurs in 10-20% of men and 10-25% of women (EUFIC, 2006), putting them at increased risk for chronic diseases (hypertension, diabetes, heart disease, cancer). In the United States, 18% adults aged above 65 years were obese and another 40% were overweight in 2000, and the total costs of overweight/obese was evaluated to be $ 117 billion (PAOA, 2002). Worse, about 300,000 Americans die annually because of obesity (WHO, 2003). The World Health Organization (WHO, 2005) estimates that 64 million people will die in 2015 and for 41 million of them the cause of death will be chronic disease. Obesity is a result of an imbalance between energy intake and expenditure towards energy excess. Consequently, the energy excess can stimulate numerous inflammatory and hormonal pathways, and cause a number diseases related to inflammation and adipose tissue (Kern et al., 1995). Some evidence suggest that excess weight and a sedentary lifestyle cause about 25% of cancer cases globally (McTiernan, 2008).

Table 1. Costs of Physical Inactivity

Health costs:
Overweight and obesity
Ischemic heart disease
Stroke
Diabetes, type 2
Hypertension
High blood cholesterol levels
Osteoporosis and related fractures
Cancer (colon, breast, bowel)
Musculoskeletal disorders (arthritis, backache)
Neurological disorders (carpal tunnel syndrome)
Mental health disorders (anexity, depression)
Other costs
Pain, disability
Longer rehabilitation times
Reduction in quality of life
Impact on workforce participation (absenteeism)
Premature deaths
Economic costs

Sources: WHO (2002), The World Health Report; British Heart Foundation (2006), 2006 Coronary heart disease statistics; London: BHF National Centre; WCRF/AICR, 2007; Friedenreich and Orenstein, 2002; Warburton et al., 2007

Direct costs of physical inactivity are associated with medical care, workers' compensation, and lost of productivity (Michigan Governor's Council, 2003). The indirect costs such as time off work and the social costs of inactivity include inefficiencies linked to replacement workers, lost opportunities, and longer rehabilitation times, additional usage of medical services (Brady et al., 1997). The economic costs of physical activity are difficult in their measurement. Oldridge (2008) states that 1.5-3.0% of total direct healthcare costs is due to physical inactivity in developed countries. Recent estimates show that in the United States about $ 75 billion was spent annually in medical costs due to physical inactivity in 2000 (Wang et al., 2004). In Canada, the direct costs of physical inactivity were calculated at about $ 2.1 billion (Katzmarzyk et al.,

2004b). It was also estimated that if Canadians reduces their physical inactivity by 10% then the costs could be reduced by $ 150 million annually. In England the total costs of physical inactivity due to direct costs of treatment for the major lifestyle diseases and the indirect costs would account for £ 8.2 billion a year (Chief Medical Officer, 2004). According to recent estimates (Medibank, 2007) the direct costs attributable to physical inactivity in Australian adults were calculated to be $ 1.5 billion.

The costs of chronic illness are due to the premature death and disability they produce. The economic costs of productivity losses accompanying the chronic illness listed in Table 1 would be avoided if adults achieved the activity levels recommended for enhancing health per week. Available evidence indicates the following order of health care expenditure attributable to physical inactivity for the chronic diseases among adults living in Minnesota: ischemic heart disease > stroke > hypertension > depression and anexity > diabetes > osteoporosis > falls > colon cancer > breast cancer (MDHFS, 2002). In turn, in Australia order of direct costs attributable to physical inactivity is slightly different: falls > CHD > diabetes > depression > stroke > colon cancer > breast cancer (Medibank, 2007). There is a lack data on physical inactivity costs from the developing countries (WHO, 2003).

Benefits of Regular Physical Activity

Regular physical activity or greater physical activity exerts beneficial effect on many aspects of health and reduces the risk of several chronic diseases. Additional benefits of physical activity include reduction of the risk of all-causes mortality of non-communicable diseases (Table 2). Numerous reports document that regular physical activity is effective in both the primary and secondary prevention of several diseases and psychological disorders. For exhaustive detail related to several systematic reviews and meta-analyses the reader is referred to the recent reviews of Warburton et al. (2006a, 2007). Two basis role of physical activity can be detailed dependently on age. Physical activity in an early age can help prevent a variety diseases. In turn, engaging in regular activity throughout life can prevent against pain and disability accompanying common diseases among older adults. Activity is particular of great importance regarding ageing of population. Estimates for the next 20 years indicate that the number of adults aged 60 years or older will increase by 100%. The benefits of regular physical activity are especially important for older people in view of the high likelihood to develop chronic diseases. Older adults are also more likely to have arthritis that can limit their physical function. These persons are sensitive to an effect of moderate intensity physical activities such as swimming, brisk walking, stretching or water exercises. Adults and ageing persons can experience improved balance, strength, flexibility, coordination, endurance, mental health, motor control and cognitive function. The improved flexibility, balance, and muscle tone protect against falls (WHO, 2003). Moreover, physical activity is effective in treating several diseases like cardiovascular,

Table 2. Health Gain and Economic and Social Benefits Obtained through Participation in Regular Physical Activity

Reduces the risk of overweight and obesity irrespective of age
Reduces the risk of cardiovascular disease (coronary heart disease, stroke, disorders of blood vessels)
Reduces the risk of developing diabetes
Reduces the risk of developing high blood pressure
Lowers blood pressure in persons who suffer from hypertension
Reduces the risk of some cancers (colon, breast, bowel, endometrial, lung, prostate)
Helps to maintain or increase muscle mass and strength
Prevents osteoporosis, bone loss and fracture
Improves function in persons with arthritis
Improves mental health
Improves quality of life and functioning irrespective of age
Reduces risk of falls and injury
Reduces feeling of anexity and depression
Reduces the risk of dying prematurely
Improves quality of sleep
Promotes psychological well-being, reduces stress
Can help the elderly adult maintain their independence longer
Helps prevent risky behaviours like use of alcohol, tobacco, and drugs
Decreases industry lost production costs
Promotes the protection of the environment
Comprises an investment in future generation
Promotes social interaction and integration
Helps reduce violence

Source: WHO (2003); BHF (2006); Warburton et al., (2006a); (2007).

high blood pressure, high cholesterol level (e.g. Bauman, 2004; Katzmarzyk et al., 2004a; Fagard and Cornelissen, 2007) chronic lung disease, obesity, diabetes, and osteoporosis (PAOA, 2002; Warburton et al. 2006a). The recent study by Portegijs et al. (2007) on mortality of 558 community dwelling 75- and 80- year-old men and women, residents of Finland, found that a high level of physical activity may decrease the risk of mortality in people with low muscle strength.

The previous meta-analysis estimate showed that high and moderate intensity of physical activity were linked to 37% and 10% reduction of mortality from CHD (Berlin and Colditz, 1990), respectively. In turn, a 9% and 21% risk reductions of incidence and mortality from ischemic stroke were reported in a meta-analysis for moderate and vigorous intensity of activity, compared with low activity (Lee et al., 2003).

Common mechanisms for the risk of CHD and ischemic stroke reduction associated with exercise and sport participation include improved endothelial function (Clarkson et al., 1999), an increase in HDL cholesterol concentrations (Kraus et al., 2002; Cavill et al., 2006), and lowering blood pressure through decreased sympathetic nervous activity (Arroll and Beaglehole, 1992; WHO, 2002; Warburton et al., 2006a). Although a

number of studies of association between physical activity and diabetes type 2 is limited, the studies indicate that more active persons have a 30-50% lower risk of developing the disease comparing to those sedentary people. Physical activity may delay or prevent glucose intolerance turning into diabetes and produce significant improvements in blood sugar level (EUFIC, 2006).

Regular physical activity reduces the risk of colorectal cancer by a 40-50% by effects on prostaglandins, reduced intestinal transit time, and increased level of antioxidants (Thune & Furberg, 2001; WCRF and AICR, 2007). Appropriate levels of physical activity reduce the risk of breast cancer average about 30-40% by changes in endogenous and metabolic hormones level, insulin and insulin growth factors concentrations, prevention of weight gain or abdominal adiposity, and by influencing immune function (Friedenreich, 2001; Westerlind, 2003; Kaaks and Lukanova, 2001; Miles, 2007; WCRF and AICR, 2007, Friedenreich and Cust, 2008; McTiernan, 2008). Physical activity is effective in reducing abdominal fatness and protects against the weight gain typical of middle age (Fogelholm and Kukkonen-Harjula, 2000). It is noteworthy that the WHO Global Strategy on Diet, Physical Activity and Health (WHO, 2003) states: "Diet and physical activity influence health both together and separately".

The health problems affecting the muscles and bones (arthritis, osteoporosis, back pain) can be reduced from regular exercise training of at least a moderately–intense level. Special designed programmes to improve muscle strength were reported to help reduce risk of falling older adults. This benefit requires doing balance and muscle-strengthening exercises every week with moderate-intensity (Van der Bij et al., 2002; CDCP, 2008). That amount of aerobic activity can prevent also against hip fractures (Nichols et al., 1994). For review of more details linked to mechanisms responsible for reduction of chronic disease and premature mortality see the last major review (Warburton et al., 2006a).

Several epidemiological studies have shown that physical activity can reduce depression and its recurring. Exercise also reduces anxiety and improve reaction to stress. In addition, physical activity appears very useful means to improve some aspects of mental functioning (e.g., short-term memory, making decision), in reduction of dementia and Alzheimer disease (Lawlor & Hopker, 2001; EUFIC, 2006), and well-being (Fox, 1999).

Next to health benefit, there is evidence that people who are physically active about 7 hours per week experience a 40% lower risk of dying early compared with those who are active for less than 30 minutes per week.

Due to both the health, economic, and social benefits of physical activity as well as the high costs of inactivity, rising obesity and diabetes, and aging populations several countries have implemented national initiatives to promote physical activity. A world-wide increase in scientific interest promotion of health enhancing physical activity during leisure time, in household and outdoor chores or at work has dated since 1994 (Martin et al., 2006). Several years later physical activity for transportation (walking, cycling, use of public transport) became object of interest. The effectiveness of interventions to increase physical activity was accelerated by growing awareness of worldwide overweight and obesity, evidence of chronic disease in children and adolescence, and ageing populations in most parts of the world.

The effectiveness of various intervention approaches and their cost associated with battling worldwide epidemic of sedentary lifestyle have been comprehensively reported and evaluated in several recent reviews (Khan et al., 2002; Briss et al., 2004; Hildson et al., 2004; Bull, 2006; Martin et al., 2006; Roux et al., 2008). The reviews have shown that there are several proven approaches to promote physical activity and to rise effectively the level of awareness in society about benefits of physical activity and participation in sports in the population of all ages. The promotion of physical activity requires effect from government and nongovernment organizations and multisectorial policy (Health, Sport, Education and Culture, Media, Urban Planning, and Transport) (WHO, 2003; Yancey et al., 2007). As physical inactivity is a societal problem, raising the level of activity needs a greater awareness in society and relevant knowledge about multiple benefits of regular activity. Among priority areas of action, particularly important are: promotion physical activity among children and adolescent, older adults, i.e. creation individually adopted health behavior change in order to make activity a daily part of people' life. It is also recommended for older adults to consult with physician amount and level of their physical activity being safe and appropriate for them.

In conclusion, physical inactivity is a modifiable risk factor for chronic diseases, overweight/obesity and some cancers. Research shows that economic costs of physical inactivity are high and affect individuals, businesses and nations. Conversely, physical activity of moderate intensity at least 30 minutes every day is often sufficient to protect against many chronic diseases, improve mental health, and well-being in women, the elderly, less fit and inactive people (Bucksch and Schlicht, 2006). In addition, longer duration and vigorous intensity may be associated with additional beneficial effects. Middle-aged men in particular might gain health benefits from activities of vigorous intensity. The study of Myers et al. (2002) pointed out that the all-cause mortality in subjects with a maximum exercise capacity of 8 METs was two times smaller than in those with capacity of less than 5 METs. According to the European Food Information Council (2006) statement "Not only does physical activity have the potential to add years to life, but the evidence is also accumulating that it can add life to years".

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