Chapter __. Physical Activity for the Prevention of Cardiometabolic Disease

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Introduction

Increased mechanization, urbanization, and technological advances are changing how and where we work, travel, and recreate. People are sitting for increasingly long hours at computers, and e-mails dominate work and communications. Social and recreational activities include using a wide variety of screen-based devices, such as televisions, smartphones, and tablets. In many countries, cars dominate transportation, creating congestion and gridlock. One-way commutes of two hours are common in cities like Bangkok, Delhi, and São Paulo. The global decline in levels of physical activity and increase in time spent in sedentary activities have contributed to major shifts in the landscape of diseases.(Archer et al. 2013, Barnett et al. 2008, Bhurosy and Jeewon 2014, Church et al. 2011, Lozano et al. 2012, Ng, Norton, and Popkin 2009, Ng and Popkin 2012, Hallal et al. 2014)

In 2014 two of every three deaths globally (38 million total) were due to noncommunicable diseases (NCDs). Physical inactivity is an established risk factor for NCDs and specifically for cardiometabolic diseases. Being inactive contributes significantly to unhealthy weight gain and obesity, high cholesterol, elevated blood pressure, and poor blood glucose levels, all of which heighten the risk of developing cardiometabolic diseases.

Physical activity itself includes different types of activity that can be done in different types of settings, including sports and recreation, play, transport-related walking and cycling, as well as movement and activities undertaken as part of daily living, such as shopping, cleaning, or climbing stairs (box __.1). These activities can be done with different degrees of effort and for different durations. Because of this breadth in modality, duration, frequency, and even location, physical activity is a complex behavior to measure, understand, and study. Nonetheless, a significant body of knowledge has accumulated on physical activity and its role in primary and secondary prevention of NCDs. This evidence is useful for informing current practice and policy in health care and other fields of public policy.

<<box __.1 about here>>

Box __.1 Definition of Physical Activity

Physical activity is "any bodily movement produced by contraction of skeletal [large] muscles that results in energy expenditure." Physical activity can incorporate a wide range of lifestyle, sport, and exercise activities.(Caspersen, Powell, and Christenson 1985, World Health 2010)

For children and young people, physical activity includes play, games, sports, walking to school, cycling, and physical education or planned exercise such as dance classes.

For adults and older adults, physical activity includes recreational or leisure-time physical activity, active transport (walking or cycling), work-related activity, household chores, play, games, and sports or planned exercise such as fitness classes.

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This chapter outlines the significant potential of public health action aimed at increasing population levels of physical activity and contributing directly and indirectly to reducing cardiometabolic diseases. It begins by providing data on global and regional levels of physical activity and on the burden of disease attributable to inactivity. This is followed by an overview of the extensive body of epidemiological evidence on the protective effects of physical activity and emerging evidence on the risk of sitting and sedentary activities, dubbed “the new smoking.”(Berry S 2013) The chapter then summarizes the most promising policy and program actions and solutions for increasing population-level physical activity and summarizes the data on the costs of inactivity for national health care systems and the cost-effectiveness of interventions. Finally, it reviews global, regional, and national policy initiatives, including the challenges and barriers to implementation.

Global Levels of Physical Inactivity

Great progress has been made in population-level monitoring of physical inactivity. Fewer than 50 countries had *any* population-level data on physical activity in 2000; of these, only 35 had data of sufficient quality and validity for inclusion in the WHO global burden of disease estimates for 2000.(Bull et al. 2004) A decade or more later, following development of the International Physical Activity Questionnaire (IPAQ)(Craig et al. 2003) and the Global Physical Activity Questionnaire (GPAQ),(Armstrong and Bull 2006) many more countries have begun to monitor physical activity. By 2014, more than 120 countries had data on physical activity in the global status report,(World Health Organisation 2014a) and it is now possible to compare patterns of participation in adults and, to a lesser extent, in young people. Furthermore, a growing number of countries have established or committed to establishing surveillance systems for monitoring physical activity, making it increasingly possible to track trends within and between countries.

Worldwide, 23 percent of the adult population is insufficiently active, defined as not achieving at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity activity or an equivalent combination per week.(World Health Organisation 2014a) Gender differences are notable in many countries. Globally 27 percent of adult women and 20 percent of adult men are insufficiently active. Regional differences are also notable, with proportions of insufficiently active adults ranging from 17 percent in South-East Asia to about 33 percent in the Americas and 38 percent in the Eastern Mediterranean(World Health Organisation 2014a) (**figure__. 1**). A concerning trend is that levels of inactivity increase with economic development. Adults are less active in high-income countries (HICs) than in LMICs (figure __.1), a pattern suggesting that inactivity will rise as middle-income countries develop economically.

<<figure __.1 about here>>

Figure __.1 Age standardized prevalence of insufficient physical activity in adults by WHO and World Bank Income group in men and women

Source: WHO Global Status Report 2014.

Less progress has been made in the systematic assessment of physical activity in young people. Few countries have a surveillance system covering ages 5–18 years. The Global School-Based Health Survey is a large, well-established survey system on health and well-being and includes several items on physical activity.(World Health Organisation 2016) However, it only assesses ages 11–17 and only reports the proportion not meeting the minimum recommended level of activity of 60 minutes of moderate-vigorous activity per day. In 2010 more than three-quarters of adolescents did not meet the recommendation. In most countries adolescent girls are less active than adolescent boys.

The rising level of inactivity in both HICs and LMICs is alarming.(Barnett et al. 2008, Ng, Norton, and Popkin 2009, Bhurosy and Jeewon 2014, Hallal et al. 2014) In the United States, studies have demonstrated large shifts in occupation-related (8–10 percent decline) and household-related (3–42 percent decline) physical activity over the past four decades.(Church et al. 2011) Using time-use surveys, Ng and Popkin (2012) modeled changes in physical activity–related energy expenditure and sedentary time for 1991 to 2030 based on current trends in Brazil, China, India, and the United Kingdom.(Ng and Popkin 2012) In these four countries, energy expenditure related to physical activity is expected to decline about 50 percent over four decades.

Premature Mortality Attributable to Physical Inactivity

Physical inactivity causes an estimated 9.0 percent of premature mortality from all causes, or between 3.1 million(Lim et al. 2013) and 5.3 million(Lee et al. 2012) premature deaths worldwide in 2010.

Physical inactivity accounts for 6.0 percent of coronary artery disease, 7.0 percent of type 2 diabetes,10.0 percent of breast cancers and 10.0 percent of colon cancers.(Lee et al. 2012) Although eliminating physical inactivity would have the largest effect on colon cancer (due to a higher hazards ratio), it would avert the largest number of cases of coronary artery disease (due to higher incidence).

Epidemiological Evidence on Physical Activity and Cardiometabolic Diseases

<<begin extract>>

In order to remain healthy, the entire day should be devoted exclusively to ways and means of increasing one's strength and staying healthy, and the best way to do so is through physical exercise. Hippocrates, Greek physician, 460–377 BC

<<end extract>>

The value of physical activity has long been recognized,(Agarwal 2012) but it is during the past 60 years that scientists have intensified efforts to measure and specify the optimal type, frequency, and duration of physical activity required for different health benefits. In 1996 a landmark report by the U.S. Surgeon General on physical activity and health shifted focus from training regimes involving shorter bouts of high-intensity exercise to a recognition of, and even greater emphasis on, the benefits of accumulating regular, sustained amounts of moderate-intensity activity (such as walking).(United States Department of Health and Human Services 1996) The report recommended that all adults should accumulate at least 30 minutes of moderate-intensity activity, through bouts of no less than 10 minutes, at least five times a week; this same volume of energy expenditure could be achieved in three 20-minute bouts of vigorous-intensity activity.(Pate et al. 1995, United States Department of Health and Human Services 1996)

The recommended threshold of activity and the underpinning scientific evidence reflected the curvilinear dose-response relationship identified from more than 30 epidemiological studies. This section provides a brief overview of some of the more recent scientific findings on the relationship between physical activity and specific cardiometabolic health outcomes.

Primary Prevention of Coronary Heart Disease

Regular moderate- or vigorous-intensity physical activity, especially leisure-time physical activity, is associated with significantly lower mortality from coronary heart disease (CHD).(Lee et al. 2012, Karjalainen et al. 2015) In a recent meta-analysis of epidemiological studies investigating physical activity and primary prevention of CHD, individuals engaging in the equivalent of 150 minutes of moderate-intensity leisure-time physical activity per week had a 14 percent lower risk of CHD than individuals reporting no leisure-time physical activity. The dose-response relationship clearly showed that undertaking some physical activity is better than none and that additional benefits occur with more physical activity.(Sattelmair et al. 2011) Persons engaging in the equivalent of 300 minutes of moderate-intensity leisure-time physical activity per week had a 20 percent lower risk than persons not engaging in any leisure-time physical activity (figure __.2).

<<figure __.2 about here>> Figure __.3 Dose-Response between Leisure-Time Physical Activity and Risk of Coronary Heart Disease

Source: Sattelmair and others 2011.(Sattelmair et al. 2011)

(permission to use this chart needs to be sought)

Primary Prevention of Type 2 Diabetes

Physical activity has a strong and inverse association with type 2 diabetes. In both cohort studies and random control intervention trials, physical activity has been shown to lower the overall risk for type 2 diabetes between 30 and 60 percent.(Ishida, Ito, and Murakami 2005, Knowler et al. 2002, Li et al. 2008, Lindstrom et al. 2006, Lindstrom et al. 2003, Ramachandran et al. 2006) A systematic review(Jeon et al. 2007) of 10 prospective cohort studies of moderate-intensity physical activity and type 2 diabetes, involving 301,221 participants and 9,367 incident cases of diabetes, found that the relative risk of developing type 2 diabetes was 31 percent lower in persons who participated regularly in physical activity compared to those who had a sedentary lifestyle (figure __.3). The results remained significant even after adjusting for body mass index (BMI). Among these studies, five investigated the role of walking.(Helmrich, Ragland, and Paffenbarger 1994, Hu et al. 1999, Hu et al. 2001, Hu et al. 2003, Weinstein et al. 2004) Walking regularly (typically brisk walking 2.5 hours per week) decreased the risk of diabetes 30 percent compared with almost no walking (figure __.4). The results included an adjustment for age, family history, educational status, smoking, alcohol, cholesterol level, and, in some instances, waist-to-hip ratio. Again, the associations remained significant even after adjusting for BMI.(Lindstrom et al. 2006)

<<figure __.3 and figure __.4 about here>>

Figure __.3 Moderate-Intensity Physical Activity and Relative Risk of Type 2 Diabetes for Individual Cohort Studies and All Studies Combined

a. Without adjustment for BMI
b. With adjustment for BMI

Source: Jeon and others (2007)

Figure __. 4 Walking and Relative Risk of Type 2 Diabetes for Individual Cohort Studies and All Studies Combined

a. Without adjustment for BMI
b. With adjustment for BMI

Source: Jeon and others (2007)

(Insert after permission (figure 1 a and b) and figure 2 a and B) from review article Jeon at al, Diabetes careVol 30, No 3, March 2007)

Impaired glucose tolerance (IGT) precedes diabetes, with two of three patients with IGT proceeding to diabetes. The conversion to diabetes is more rapid in India and South-East Asian countries than globally.(Mohan et al. 2006, Ramachandran et al. 2006) More than 77 percent of the 316 million people with IGT worldwide live in LMICs and are 20–39 years old.(Li et al. 2008) Two landmark clinical trials—the Diabetes Prevention Program(Knowler et al. 2002) and the Finnish Diabetes Prevention Trial,(Folsom, Kushi, and Hong 2000, Weinstein et al. 2004) followed by many other trials established that physical activity combined with dietary modulation can lower the risk of diabetes in individuals with impaired fasting glucose or IGT. What is remarkable is that some studies have shown the beneficial effects persisted for 10 years or more.(Perreault et al. 2009, Weinstein et al. 2004) Collectively, these studies provide strong evidence that behavioral interventions, and specifically those aimed at encouraging regular physical activity, are effective for tackling diabetes at the population level including in developing countries.(American Diabetes Association 2014, Goenka 2008, Goenka et al. 2007, Goenka et al. 2009)

Secondary Prevention of Type 2 Diabetes

Physical activity plays a major role in secondary prevention of type 2 diabetes. Studies have shown that blood pressure higher than 115/75 millimeters of mercury (mmHg) is associated with higher rates of cardiovascular events and mortality in individuals with diabetes and that systolic blood pressure greater than 120 predicts long-term end-stage renal disease.(Chobanian et al. 2003, Stamler et al. 1993, UK Prospective Diabetes Study Group 1998) Conversely in people with type 2 diabetes, lower blood pressure lowers the risk of cardiovascular disease. Randomized clinical trials have demonstrated that lowering blood pressure to 140/80 lowers the risk for CHD events, strokes, and nephropathy in persons with diabetes.(Adler et al. 2000, UK Prospective Diabetes Study Group 1998) Increasing regular physical activity through activities of everyday living can significantly lower these risks.

Figueira and others (2014) conducted a systematic review and meta-analysis of 30 random control clinical trials of structured training programs (2,217 patients) and 21 studies of the effectiveness of providing advice on physical activity (7,323 patients).(Figueira et al. 2014) Their aim was to assess the effect on blood pressure of structured exercise (aerobic, resistance, or combined) and the effect of physical activity advice alone in patients with type 2 diabetes. Structured exercise was associated with reductions in the weighed mean difference (WMD) of −4.22 mmHg for systolic and −2.07 mmHg for diastolic blood pressure versus controls. In addition, structured exercise of greater than 150 minutes per week was associated with an even greater reduction in blood pressure. Advice alone was associated with a reduction in WMD of −2.97 mmHg and −1.41 mmHg for systolic and diastolic blood pressure, respectively, versus controls.(Figueira et al. 2014)

Primary Prevention of Hypertension

Approximately 34 percent of hypertension could be prevented if adults would increase their physical activity and fitness.(Carnethon et al. 2010, Pereira et al. 1999) The Coronary Artery Risk Development in Young Adults (CARDIA), a longitudinal study of cardiovascular disease risk factors in adults ages 18–30 years, showed that participants who were physically active had lower risk for incident hypertension than those who were the least active, after adjusting for race, sex, age, education, and family history of high blood pressure.(Parker et al. 2007) Young adults who were the most physically active had a lower risk of developing hypertension, although the risk was attenuated after adjusting for fasting insulin level and waist circumference. While some of the association between activity and incident hypertension may have been mediated by obesity and the metabolic syndrome, both insulin levels and waist circumference are part of the causal pathway and thus adjusting for them results in over adjustment.

Carnethon and others (2010) extended Parker's study by adding another five years and found benefits higher levels of fitness were significantly and inversely associated with the development of hypertension within each tertile of physical activity.(Carnethon et al. 2010) The relationship was strongest among participants who were the most fit and this pattern was similar across all tertiles of physical activity.(Carnethon et al. 2010)

Atherosclerosis Risk in Communities (ARIC) was a population-based prospective study with more than 7,400 adults ages 45–65. After adjustment white men in the highest quartile of sport index and leisure index had significant reductions in the odds of developing hypertension of 23 percent and 34 percent respectively, compared to men in the lowest quartiles.(Pereira et al. 1999) This relationship was not significant for black men or women. The authors suggest this may be due to the validity of the exposure measure in these sub populations. Similar findings were reported in the Henry Ford Exercise Testing Project which found those with the highest level of fitness had a 20 percent lower risk of incident hypertension than persons with the lowest level of fitness.(Juraschek et al. 2014) In this study the relationship was observed across strata of age, sex, race, obesity, resting blood pressure, and diabetes.(Juraschek et al. 2014)

Sedentary Activity and Sitting: Emerging Risk Factors

There is increasing evidence that time spent in prolonged, particularly uninterrupted, "sitting" is a risk factor for cardiovascular and other-cause mortality and associated co-morbidities, including higher waist circumference and obesity, IGT and insulin resistance, systemic inflammation, and elevated blood pressure, even after adjusting for levels of moderate-to-vigorous physical activity.(de Heer et al. 2012, Dunstan et al. 2010, Dunstan, Thorp, and Healy 2011, Healy et al. 2008) Patel and colleagues (2010) assessed the relationship between sitting and physical activity and total mortality in a large prospective study of US adults. Results showed time spent sitting (≥6 versus <3 hours/day) was associated with mortality in both women (relative risk 1.34, 95% CI: 1.25, 1.44) and men (relative risk 1.17, 95% CI: 1.11, 1.24), after adjustment for smoking, body mass index, and other factors. These associations were strongest for cardiovascular disease mortality. Interestingly, interrupting or breaking up the time spent sitting with short bouts of physical activity has been shown to be associated with lower blood pressure, two-hour plasma glucose, triglycerides, waist circumference and BMI.(Healy et al. 2008, Larsen et al. 2014)

For example in a hospital-based, cross-over randomized trial, patients were given a test drink of 75 grams of glucose and 50 grams of fat, and their acute metabolic response was documented for five hours thereafter. When these five hours were interrupted every 20 minutes with two minutes of light-moderate physical activity, as compared to uninterrupted sitting, patients experienced a 23–26 percent benefit for the "area under the curve" on the post-prandial plasma glucose and insulin levels.(Dunstan et al. 2012) Other cross-sectional cohort studies and intervention trials also illustrated the risks of remaining sedentary for long durations and the benefits of breaking up sitting and collectively indicate that public health actions are warranted to both increase physical activity *and* reduce time spent sitting.

Objective measuring devices are the preferred instrument to monitor the amount of time spent sitting and in sedentary activities, which is difficult to recall accurately.(Wijndaele et al. 2015) Nonetheless, items to collect self-reported time spent sitting were included in IPAQ and GPAQ and results from recent pooled analysis(Hallal et al. 2012) found that more than 41 percent of the adult population globally spend more than four hours a day sitting (figure __.5). Notably, adults over 60 years of age were more sedentary than younger adults but otherwise there was little difference by gender. There were also regional differences, with the highest prevalence of sedentary activity in the Middle East (64 percent) and the lowest in South-East Asia (24 percent) (data not shown).

<<figure __.5 and figure about here>>

Figure __.5 Proportion of Individuals Reporting Sitting for Four or More Hours a Day

Source: Hallal and others (2012)(Hallal et al. 2012)

Summary of the Evidence

Physical activity has well-known benefits for the prevention and management of chronic cardiometabolic diseases. However, in addition regular physical activity provides numerous other health and social benefits, such as preventing and treating depression and anxiety,(Warburton, Nicol, and Bredin 2006) preventing cognitive decline and dementia,(Scholz et al. 2009) preventing falls and promoting independent living in older adults,(Sherrington et al. 2008) and preventing osteoporosis by generating and maintaining peak bone mass.(Bielemann, Martinez-Mesa, and Gigante 2014, Bielemann, Martinez-Mesa, and Gigante 2013, Kemmler et al. 2015) Physical activity is important across the whole life span, and for children, for whom regular active play and recreation promotes healthy growth and development, fitness, and healthy weight and can improve cognitive development and academic performance.(Singh et al. 2012) With the many well-established benefits, physical activity is a major contributor to overall physical, social and mental well-being.

Interventions to Increase Population-Level Physical Activity

There is growing interest in learning how to increase population-level participation in physical activity and rising demand for clear policy direction supported by robust evidence on the effectiveness of strategies that are transferable to diverse settings and contexts globally. Although research undertaken in Australia and New Zealand, Europe, and North America dominates this field, evidence from LMICs has been accumulating, including systematic reviews.(Hoehner et al. 2008) Governments in Australia, the United Kingdom, and the United States have periodically reviewed the evidence to produce national guidance and support their policy development (see online Annex **__.1** for references), but until recently there were few global resources providing easily accessible, credible sources of information with global applicability on what works to increase physical activity. To fill this gap, the Global Advocacy for Physical Activity (GAPA) Initiative developed a “blueprint” for a settings-based, population approach to increasing physical activity.(Global Advocacy on Physical Activity (GAPA) 2012) The resulting document, *Seven Investments That Work***,** provides a framework for national action on physical activity that is applicable to all countries (box __.2). A strong body of research supports the importance of each of these areas. Schools, primary health care, and communities are well-established settings for primary prevention, including programs that address physical inactivity. The transportation sector and urban environment provide are more recent sectors to work with and each are important because they provide the infrastructure for physical activities, such as on- and off-road cycle paths, footpaths, pedestrian crossings, sporting and recreational facilities, and public open spaces.

This section identifies some of the benefits of programs in these settings and key barriers to scaling up implementation.

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Box __.2 What Works to Increase Physical Activity: Seven investments for action

The GAPA framework is set across seven settings:

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- *Whole-of-school programs*, including regular, quality opportunities for physical education and activity for all children before, during, and after the school day
- *Transport policies and infrastructure* that prioritize and support safe, accessible walking, cycling, and use of public transport
- *Urban planning design and regulations* that support equitable and safe access to walking, cycling, recreational, and sporting opportunities
- *Primary health care* that promotes and integrates physical activity in patient risk assessment systems and primary and secondary care pathways
- *Public education campaigns* that raise health awareness of physical activity and create positive social norms
- *Sports systems and programs* that promote “sports for development” or “sports for all” and encourage participation across the life span
- *Community-based programs* that provide spaces and programs tailored to the community’s cultures and traditions.

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Source: Global Advocacy on Physical Activity (2012).(Global Advocacy on Physical Activity (GAPA) 2012)

Whole-of-School Programs

There is substantial evidence that “whole-of-school” programs can promote physical activity by ensuring that physical education takes place regularly and that classes provide opportunities for students to be highly active.(Kemmler et al. 2015) In addition, schools should provide activity-permissive environments, within the limitations of their resources, to support both structured and unstructured play and physical activity throughout the day. Whole-of-school approaches generally should include supporting safe, active travel to and from school, creating an enabling policy environment, and engaging parents, teachers, students, and members of the surrounding communities.(Global Advocacy on Physical Activity (GAPA) 2012) The key principles of this approach have also been shown to be effective in resource-constrained contexts, such as in Latin America.(Ribeiro et al. 2010)

Although there are some good examples around the world, to date very few countries have implemented a comprehensive national school strategy, particularly in LMICs, where competing priorities, lack of resources and weak enforcement of the legislative and policy structures are common.

Urban Planning and Transport Policies

The need for supportive policy, programs, and systems within the transport and urban design sector has been recognized for well over a decade,(Sallis, Bauman, and Pratt 1998) nd a strong body of evidence shows consistent associations between urban and transport design and physical activity in HIC and LMIC.(Adams et al. 2013) Yet in many developing countries, cities are gridlocked and overcrowded, and new developments priority is given usually to providing infrastructure for motor vehicles and the needs of pedestrians and cyclists are neglected, particularly in economically marginalized communities. In India, for example, persons living in economically marginalized localities lack pedestrian pathways or cycling pathways and have few recreational facilities.(Goenka et al. 2007, Goenka et al. 2009)

Interventions to support and promote safe, walking and cycling (i.e., ‘active transport’) is a practical and sustainable way to increase daily physical activity and will provide additional benefits such as reduced traffic congestion and CO_2 emissions. Increasing active transport requires a supportive transport and planning policy frameworks that influence land use allocation and infrastructure for walking, cycling, and public transport. When combined with effective promotional programs this can shift mode choice away from personal motorised vehicles and increase physical activity.(Global Advocacy on Physical Activity (GAPA) 2012)

Examples of successful actions in these sectors are available (New York State Government 2010, Pratt, Perez, et al. 2015) although more evidence is needed, particularly from longitudinal evaluations using robust measures of both exposure and outcomes.(Paez et al. 2015)

Several countries have made positive strides in urban planning to support physical activity. In Bogota (Colombia)(Torres et al. 2013) and Recife (Brazil)(Reis et al. 2010) the provision of off-road cycle and footpaths and the closure of roads to motorized vehicles provided improved access to safe and enjoyable places to be active and made cycling and walking a safe and convenient form of transport for short trips. (see Box 3 and 4) These case studies show at a city level what can be done to change the urban form and facilitate active living.

<<Insert Box 3 and 4 about here - case studies Columba and Brazil>>

Primary Health Care

A well-established evidence base supports the effectiveness of health care providers screening and counselling patients on physical activity as part of primary and secondary prevention care pathways. A typical approach includes screening patients for physical activity as a "vital sign" for NCD prevention, brief behavioral counseling by a doctor or health care professional, and referral to a community-based program.(Arena, Harrington, and Després 2015) Often called "exercise by prescription," this approach has been integrated into the primary health care system of countries such as New Zealand and the United Kingdom as well as that of some health care providers in the United States.

One of the earliest examples, New Zealand's Green Prescription (GRx) has been scaled-up to a national level through partnerships with general practitioner groups and the Ministry of Sports and Recreation and with funding from the Ministry of Health (**See online annex __.2**).<< Begin here>> The GRx is issued by a general practitioner or practice nurse, in written form or electronically, after an initial assessment. GRx is then forwarded to the nearest GRx support person (a physical activity specialist), who makes contact with and encourages the patient to become more physically active through monthly phone calls or face-to-face meetings for three to four months or through community support groups for three to six months. Patient progress is reported back to the referring health professional and if required, the GRx can be refilled. An extensive body of peer-reviewed literature has found the GRx to be effective in changing self-reported and pedometer-measured levels of physical activity and also to be cost-effective.(Croteau, Schofield, and McLean 2006, Elley et al. 2003) The most likely persons to be referred are those with a chronic condition, older adults, or overweight persons,(Croteau, Schofield, and McLean 2006) he GRx has been found to be acceptable across a variety of cultural groups in New Zealand.(Tava'e and Nosa 2012)<<End here>>

Such initiatives can also be found in Sweden(Kallings et al. 2008) the United Kingdom(Boehler et al. 2011) and elsewhere.(Sørensen, Skovgaard, and Puggaard 2006) The American College of Sports Medicine has initiated a global initiative, "Exercise Is Medicine" (Lobelo, Stoutenberg, and Hutber 2014) to expand this concept to more countries.

Public Education Campaigns

Mass media provides an effective way to transmit consistent and clear messages about physical activity to large populations. It can include use of paid and non-paid forms of media to raise awareness, increase knowledge and shift community norms to motivate populations to be more active.(Cavill and Bauman 2004) Public education can involve print, audio and electronic media, outdoor billboards and posters, public relations, point of decision prompts, mass participation events, mass distribution of information as well as new media such as text messaging, social networking and other uses of the internet. Combinations of these approaches, supported by well-coordinated community-based events and sustained over time are most effective.(Leavy et al. 2011) Public education is an identified 'best buy' recommendation by the World Health Organisation,(World Health Organisation 2014b) and there are many examples from high and middle income countries of effective use of this approach.(Leavy et al. 2011)

Sports Systems and Sports-based Programs

There are obvious synergies between the promotion of physical activity and sports participation given that sport is, by definition, involves physical activity. However, not all sports programs aim to encourage mass participation and instead focus on high performance and elite competitions. Yet, physical activity could be increased through greater engagement with community sport programs, particularly those run using '*Sport for All'* principles.(International Olympic Committee 2014) Building on the universal appeal of sport, a comprehensive and inclusive sport system should include the adaption of all sports to provide a range of opportunities to match the interests, skills and capabilities of men and women, girls and boys of all ages. Sports for All initiatives focus on the democratization of, and mass participation in, sports and recreation and aim to improve health and social inclusion through sports, particularly for vulnerable groups, such as the poor, the elderly and women.(Cousineau, Collins, and Cooper 1998) With a strong focus on enjoyment, Sports for All programs are usually community-based, culturally-adapted, inclusive and build on partnerships between local sporting clubs, municipal sports and recreational authorities, and sports organizational committees and councils.(Cousineau, Collins, and Cooper 1998, Marlier et al. 2015) Sports for All programs can also address inequalities (See Box 5).

Promotion of physical activity is aligned with the United Nations Sports for Development and Peace Initiative".(United Nations 2016) This program focuses on promoting the benefits of sports participation and social outcomes such as increasing social capital, providing diversionary activities, changing social norms, and selected health issues Grassroots Soccer (, Fenton, Duda, and Barrett 2014) is a well-known initiatives typically practiced in low-income settings. It has increased awareness of, and lower stigma regarding HIV/AIDS and contributed significantly to achieving the recommended guidelines for moderate-to-vigorous activity for youth.(Fenton, Duda, and Barrett 2014)

<<box __.5 about here>>

Box __.5 Gender Issues and Physical Activity

In many cultures, girls and women have fewer opportunities to participate in physical activities than boys and men. For example, customs and cultural norms related to women's clothing may make it difficult for women and girls to be physically active, and societal values may prohibit women from being active in public. These barriers can be overcome by providing women-only, culturally acceptable opportunities and facilities, although resources are scarce and not always available for separate facilities and programs.

The recently agreed Sustainable Development Goals(United Nations 2015) addresses gender inequalities, with several targets related to equitable educational environments and opportunities for women and girls.

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Another example of a successful sports based program is “Football Fans in Training” which has incorporated attributes of community-wide programs and the ‘health-through-sport’ conceptual model. It targetstypically hard-to-reach men from low-income communities in Scotland and provides weekly physical activity sessions at a professional soccer club along with nutrition information, and follow-up. The results showed significant weight loss, reduction in waist circumference, body fat and blood pressure, as well as improvements in physical activity compared with the control group (which received information only).(Hunt et al. 2014) Furthermore, there was minimal loss at follow-up and has been shown to be cost-effective and can attract and retain men at-risk of cardiometabolic diesases.(Hunt et al. 2014)

Community-Based Programs

Community-based programs including those offering exercise classes in public spaces have also shown great promise, particularly in low-income settings in HICs and LMICs. In Brazil, the Academia da Cidade, which started in 2002 by the Health Secretary of the City of Recife, has grown to more than 30,000 participants in its 19 “polos” (community settings such as public parks).(Pratt, Perez, et al. 2015) Classes generally take place early in the morning or after work, include lifestyle counseling, are run by qualified exercise professionals and are free to the general public. Similar programs exist in other cities and the Brazilian government intends to extend the program to more than 4,000 new municipalities over a five-year period. In Colombia, Bogotá holds a city-sponsored, community-wide physical activity program, known as Muévete Bogotá and Recreovia, in public parks. Similar free community based program are becoming increasingly popular in high income countries and can form important part of a a national physical activity strategy and network.

Economic Costs of Physical Inactivity

Prior to the 1990s, there was virtually no published data addressing the costs of inactivity. However, with the development of better measures of exposure and increasing availability of data on disease-specific health care costs, studies have now been conducted to assess the direct costs of inactivity to national health care systems in more than a dozen mostly high-income countries.

Online annex __.3 provides a summary of recent studies using the cost-of-illness approach and reporting estimates of the direct health care costs attributable to physical inactivity.

<<online annex__.3 about here>>

Pratt and others (2014) synthesized 11 published estimates from six HICs and despite heterogeneity between studies and health systems, they found consistent results of between 1.0 and 2.6 percent of total health care costs (for the selected health outcomes) attributed to inactivity. (Pratt et al. 2014) Higher estimates were explained by the inclusion of additional health outcomes over and above CHD, stroke, diabetes, and cancer. for example, osteoporosis, musculoskeletal conditions (i.e., hip fractures and falls), and mental health issues (such as depression).(Colditz 1999, Katzmarzyk, Gledhill, and Shephard 2000) Including these additional conditions can yield estimates of direct health care costs of well over 1 billion in national currencies. This may appear high, but given the substantial evidence on the role of physical activity in the prevention and treatment of other health outcomes, estimates which exclude these conditions are generally viewed as conservative. Whilst desirable, including these other conditions is frequently hampered by a lack of reliable data, especially in LMICs.

Studies from developing countries such as São Paulo (Brazil) and Bogotá (Colombia) provide similar estimates of total direct health care costs (3.3 and 2.5 percent, respectively). Whilst in Eastern Europe, a recent analysis from the Czech Republic(Maresova 2014) reported that physical inactivity caused an estimated 2,442 deaths, or 2.3 percent of all deaths, 1.2 percent of all disability-adjusted life years (DALY), and almost CZK 700 million (US$29 million), or 0.4 percent, of total health care costs for public insurance companies.(Maresova 2014) In China, Popkin and others (2006) reported estimates of US$1 billion in direct medical costs of physical inactivity for 2001and projected this to reach 8.7 percent by 2025.(Popkin et al. 2006)

Most of the economic evidence to date has estimated direct health care costs however, the *indirect* costs of inactivity include the value of economic outputs lost because of illness (productivity lost due to sickness and absenteeism), injury-related work disability, or premature death before retirement as well as privately incurred health care costs and informal care for persons with NCDs. Furthermore, a complete analysis should also include the costs of being active (equipment) and the costs of the consequences of activity (such as injuries and lost productivity due to injuries). Few scholars have taken such a comprehensive approach, although Katzmarzyk and Janssen (2014)(Katzmarzyk and Janssen 2004) estimated the total economic burden of physical inactivity in Canada in 2001 to be Can$5.3 billion (US$4 billion), of which Can$1.6 billion (US$1.2 billion), were direct costs and Can$3.7 billion (US$2.8 billion), were indirect costs.(Katzmarzyk and Janssen 2004)

Another example is from the United Kingdom, where the national policy on sports and physical activity ‘Game Plan’ reported that inactivity cost almost £2 billion (US$2.8 billion) a year, of which £0.3 billion (US$0.4 billion) were direct costs to the national health system, £0.8 billion (US$1.1 billion) were due to absence from work, and £0.8 billion (US$1.1 billion) were due to premature mortality.(Department of Culture Media and Sports 2002, Scarborough et al. 2011) Modeling of total costs using higher levels of inactivity and a wider range of health outcomes (including lower back pain) produced estimates up to £8 billion (US$11.5 billion) a year, though some challenge these estimates due to the lack of transparency of methods. (Allender et al. 2007) Nonetheless, the Game Plan report illustrates a more sophisticated approach to incorporating all costs and benefits of inactivity in a model.

Modeling of change in level of activity has been done in several countries. In Northern Ireland reducing inactivity from 20 to 15 percent could save £0.62 million (US$0.89 million) in avoidable health care costs. This estimate was considered conservative because it excluded adults over 75 years of age. In New Zealand, reducing inactivity from 31 to 21 percent was estimated to potentially save $NZ 48 / US$ 32 million a year whilst in Australia, a 10 percent reduction was estimated to save 25,000 of the 174,000 attributable DALYs and save the health care sector $A 96 million (US$72.6 million) (about 14 percent of annual health sector costs).(Cadilhac et al. 2011)

To date the economic arguments for savings in health care costs are not used extensively, at least at the global level. This may reflect the heterogeneity of current evidence and suggests there is a need for greater international collaboration to develop capacity in this field. Gaps in evidence include more estimates from LMICs, estimates of total costs (including wider societal impacts) and estimates of cost savings for specific subpopulations, particularly women, high-risk patients, and older adults. The development of extensive global, regional, and national data sets on the burden of disease provides a strong foundation and good opportunity for this field to mature rapidly in the next three to five years.

Cost-Effectiveness of Physical Activity Interventions

Several recent reviews provide estimates of the cost-effectiveness of population-level physical activity interventions.(Laine et al. 2014) Laine and others (2014) converted the costs of interventions into costs per person per day in 2012 U.S. dollars. The physical activity results were calculated as the metabolic equivalent of task hours (MET-h) gained per person per day. The results showed population-based interventions such as providing opportunities for biking and cycling were found to be cost-effective (US$0.006 per MET-h) as were school-based education programs (US$0.056 per MET-h), point-of-decision prompts to promote stair use (US$0.07 per MET-h per person per day) and the use of pedometers (US$0.014 per MET-h).(Laine et al. 2014) Individually based interventions that sought to affect the behavior of individuals were the least cost-effective, but had the largest effects.(Wu et al. 2011) Whilst in primary care settings, Garrett and others (2011)(Garrett et al. 2011)estimated the cost to move one person to the 'active' category at 12 months ranged from €331 to €3,673 (US$ 369- US$ 4,095). The cost-utility was estimated varied across nine studies from €348 (US$ 388) to €86,877 (US$ 96,865) per quality-adjusted life year (QALY).

Earlier work by Roux and colleagues (2008)(Roux et al. 2008) conducted a lifetime cost-effectiveness analysis from a societal perspective to estimate the costs, health gains, and cost-effectiveness (dollars per QALY gained) of seven public health interventions recommended by the Task Force on Community Preventive Services to promote physical activity in a simulated cohort of healthy U.S. adults stratified by age, gender, and physical activity level. The interventions were : community-wide campaigns, individually adapted health behavior change, community social support interventions, and creation or enhancement of access to information on and opportunities for physical activity and each was compared to the alternative of no intervention. Cost-effectiveness ratios ranged between US$ 14,000 and US$ 69,000 per QALY gained. Results were sensitive to intervention-related costs and effect size.

Global Progress in Public Policy

The WHO developed the first Global Strategy on Diet and Physical Activity in 2004. Although physical inactivity was recognized in some earlier resolutions,(World Health Organization 2004) the 2004 strategy provided the first detailed guidance on national actions to increase physical activity and decrease sedentary activity globally. The 2011 United Nations meeting and subsequent declaration(United Nations 2011) and the WHO "Global Action Plan on the Prevention and Treatment of NCDs 2013–2020"(World Health Organisation 2014b) provided a strong foundation for including physical activity in national NCD policies. The monitoring and evaluation framework requested by the United Nations and led by the WHO resulted in a global target to reduce inactivity 10 percent by 2025.(World Health Organisation 2014b)

Many Scandinavian and Western European countries developed national policies on physical activity in the late 1990s, stimulated and supported by the 1996 U.S. Surgeon General's report and international consensus on the benefits of physical activity. Reviews of national policy approaches have identified some similarities, but also differences. (Bull et al. 2015, Bull et al. 2014, Daugbjerg et al. 2009) Physical activity was frequently considered as part of healthy eating and obesity policy or as part of sports and youth policy rather than as a standalone policy. Often no policy goal or target was given for increasing the prevalence of physical activity, and no systematic population surveillance system was created to track trends. Policy implementation was weak or inconsistent, and evaluation was rarely systematic. Despite having national policies to increase physical activity, countries such as Australia, England, Norway, Scotland, and Wales devote inadequate resources to implementation and suffer from limited workforce capacity.(Bull and Bauman 2011)

In LMICs, progress in developing and implementing national physical activity policies and actions has been much slower, despite a significant increase in the last three years. Indeed, the proportion of countries with a policy on physical activity rose from as low as 29 percent in 2005 to 73 percent in 2010 and to 80 percent in 2013.(World Health Organisation 2015) Monitoring policy is an emerging area, and direct comparison across years of the WHO survey is not possible due to variations in methods and questions. Furthermore, the validity of the responses was not verified before 2013 or 2015. These additional questions revealed that, although 80 percent of the countries reportedly had a policy on physical activity in 2013, only 56 percent had an operational policy—that is, a policy that was active and funded. An important gap exists between having a policy and implementing it.

Other reporting systems developed by civil society(Pratt, Ramirez, et al. 2015, Tremblay et al. 2014) are also providing data useful for assessing individual country progress and between country comparison. Report cards vary in the content, level of detail and intended audience. The Policy Audit Tool was developed to collect a comprehensive analysis of physical activity policy for an individual country, with the goal of developing collaborations between disciplines and sectors.(Bull et al. 2015) Used in Europe(Bull et al. 2015) and the Middle East,(World Health Organisation 2014b) the Policy Audit Tool provides policy makers with a situational analysis of current policy and actions that can inform decision making and investment as well as support partnerships between sectors.

Gathering examples of country action is useful for sharing lessons of what did and did not work. For example, Brazil, Canada, Colombia, and Finland provide interesting comparisons. Both Brazil and Colombia developed their national programs from a base of well-evaluated city-scale programs in contrast Canada implemented a sustained national mass media campaign (ParticPACTION) over decades to promote the benefits of physical activity and establish strong and enduring awareness in the community.(Pratt, Perez, et al. 2015) Finland benefited from the strong cultural value placed on physical activity combined with a steady flow of supportive programs, local government grant system and other initiatives coordinated by a national steering committee. Both Finland and Canada had good preexisting infrastructure, public open spaces, an urban environment conducive to physical activity in daily living, as well as a lower density of population and greater socioeconomic equity than Brazil and Colombia. Despite differences in context and approaches, these countries have experienced success because they cultivated political support, secured sustained leadership from key agencies and made large-scale efforts to secure community engagement.

Conclusions

A strong body of evidence supports the benefits of promoting physical activity to reduce cardiometabolic disease. Economic analyses conducted in a variety of countries indicate that between 3 and 6 percent of national health care costs are attributable to physical inactivity. There is also good evidence that effective interventions can increase population-level physical activity by encouraging activities of daily living and providing opportunities for sports and recreational activity. National policy recommendations include implementing population-based strategies to provide the supportive environments that make physical activity possible, accessible, and desirable, combined with interventions and programs that enhance the knowledge and social value of physical activity, particularly in countries where physical activity is not socially or culturally viewed as desirable. Although there is a strong framework of global policy and consensus-based recommendations on physical activity, in most countries, particularly LMICs, a significant disconnect exists between the scientific evidence, public health need, and implementation on the ground. The challenge is to find ways to translate evidence into effective public health action within the context of rising levels of inactivity at work, during transport, and during recreation.

National policy makers need to identify and address the gaps in implementation. Examples of successful implementation show how physical activity can be increased through sustained multisectoral policy actions. Key elements of success are engaging stakeholders and working in partnership across ministries and portfolios. Establishing and maintaining such partnerships are challenging for all governments. However, many of the determinants of active living lie outside of the health sector, and such partnerships are essential for sustained success in increasing national levels of physical activity.

Individually targeted behavior change programs will be unsuccessful or short-lived without changing the environment. Site-specific interventions in schools, primary health care, and worksites have been shown to provide significant benefits.

Strategies to promote physical activity include providing a supportive environment for safe, enjoyable physical activity in daily living and promoting active transport. These strategies must be contextualized to the country. Strong political leadership, combined with participatory approaches and community engagement, are critical to success.

Box 3 Community based programs in Brazil

Academia da Cidade, was initiated in the city of Recife, a state capital in the Northeast of Brazil and provides free daily physical activity classes in early mornings and late afternoons led by trained physical educators. Restructuring and re-engineering of public parks or plazas, often in poor and dangerous neighbourhoods, increased provision of safe public spaces in the community for physical activity along with good equipment and supervision. A strong connection with the public primary health care system allowed for easy referrals for prevention and treatment of NCD. Program evaluation showed positive results and now several cities in Brazil have adapted the model and it has expanded to more than 400 cities delivering community classes and improving the infrastructure to support physical activity.(Simoes et al. 2009)

Agita Sao Paulo (Move-up Sao Paulo) aims to increase knowledge of the benefits of and levels of physical activity in the general population. The program name itself, *Agita,* is a strong idiomatic expression that means much more than just move your body, it also means move your mind, move your citizenship, be ready for change.(Matsudo et al. 2002) It has a focus on students, workplace, and community and applies an ecological model with strategies aimed at addressing the intra-personal, social and physical environment factors that influence physical activity.(Matsudo et al. 2004) Evaluation showed high levels of program awareness, an increase in physical activity and reduction in sitting time. Key success factors include:

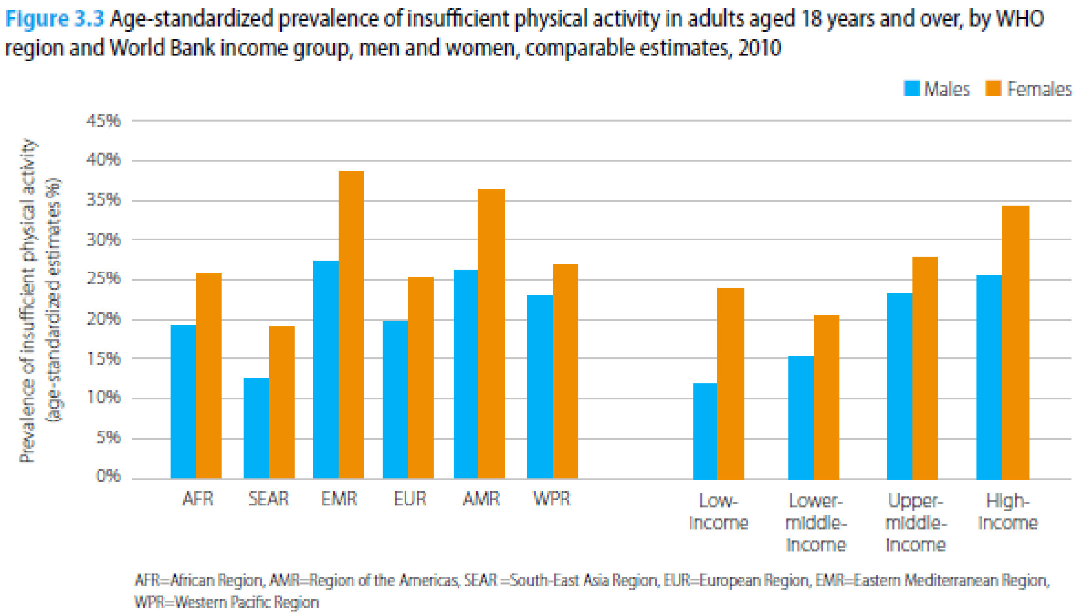
- a clear message promoting at least 30 minutes of physical activity per day;
- use of social marketing and a successful program logo and group of mascots (e.g., the Half-Hour Woman (Figure 6));

- strong inter-sectoral and intra- sectoral partnerships involving government, non-governmental and private sectors;
- targeting of sub populations with tailored messages and exploiting cultural links;
- combining permanent actions with large ‘mega’ events (e.g. Agita Galera involves almost 6 million students from over 6 thousand schools;
- maximal use of unpaid mass media for promotion;
- capacity building across 17 regional Departments of Health covering 645 cities.

Agita Sao Paulo was led and coordinated by the Studies Center of the Physical Fitness Research Laboratory of São Caetano do Sul (CELAFISCS).

Box 4 Community based programs in Columbia

In **Columbia**, a number of city programs began in the 1990s forming a national physical activity network in 2002. In 2008 an intersectoral government commission for physical activity was created and in 2009 the Colombian congress passed a national obesity law that included strategies for improving environments, policies, and programs for physical activity. The National Development Plan 2010–2014 included physical activity promotion as a priority, with specific ten-year plans for sports, recreation, physical education, and public health. Stimulated by both supportive policies and local programs the national sports institute (Coldeportes) launched a national physical activity program focused on training public health and PA professionals across Colombia to deliver community-based programs modelled on Muévete Bogota,(Gámez et al. 2006) and the ciclovías of Bogotá, Medellin, and Cali (open streets programs).(Sarmiento et al. 2010) Free physical activity classes in public parks, plazas, and community centers similar to those in Brazil, and a network of 67 open streets programs (Vías Activas y Saludables) are key components of the national program.



Source: WHO Global Status Report 2014. (WHO 2014)

Figure 1 Age standardized prevalence of insufficient physical activity in adults by WHO and World Bank Income group in men and women

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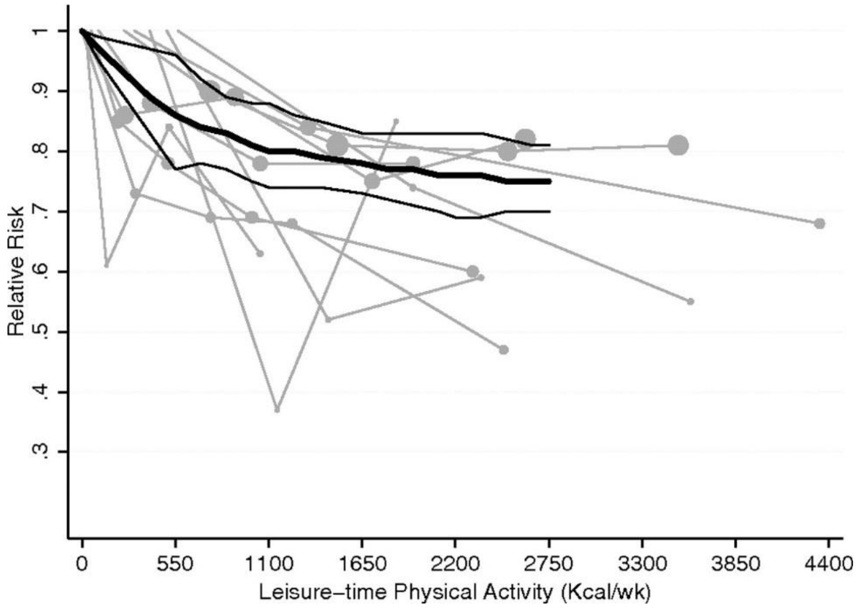
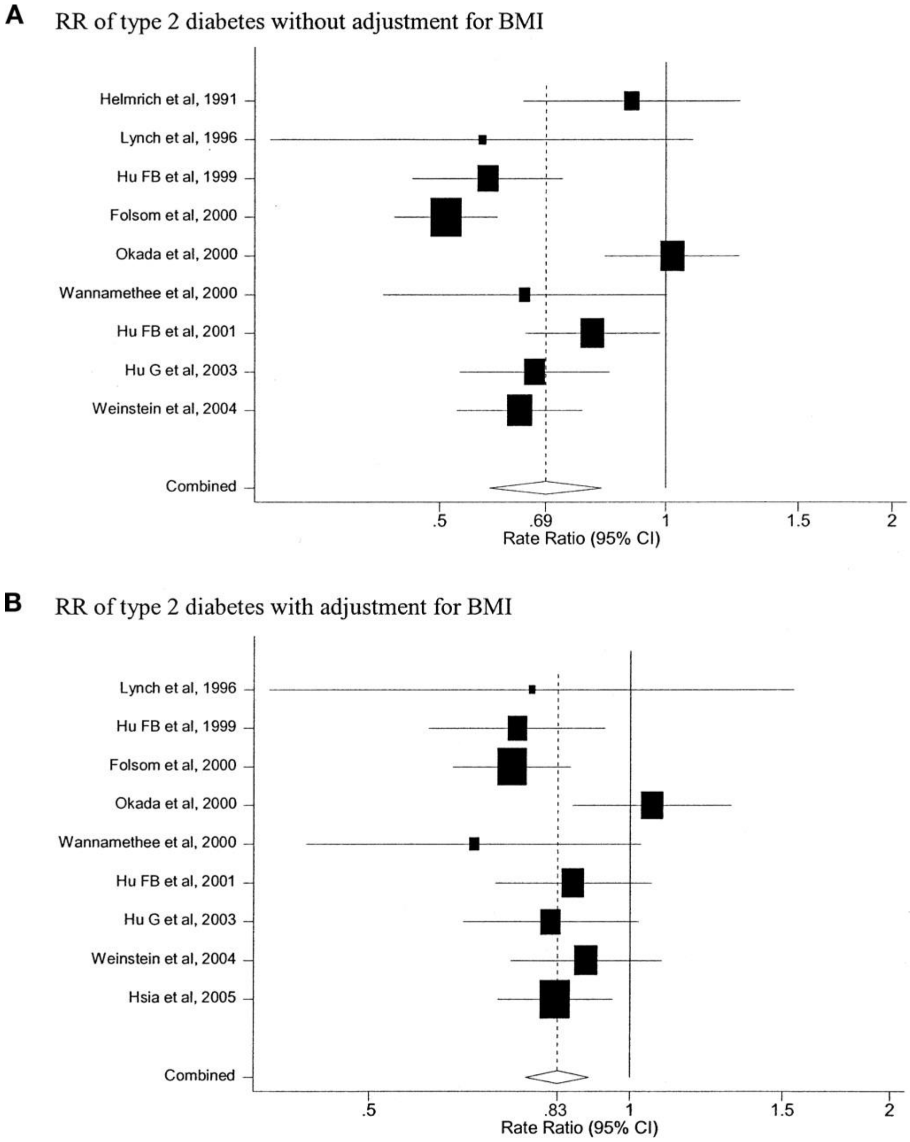


Figure 2. Summary of the dose response between leisure-time physical activity and risk of coronary heart disease.

Source : Sattelmair et al., 2011 [72]

(permission neeed)

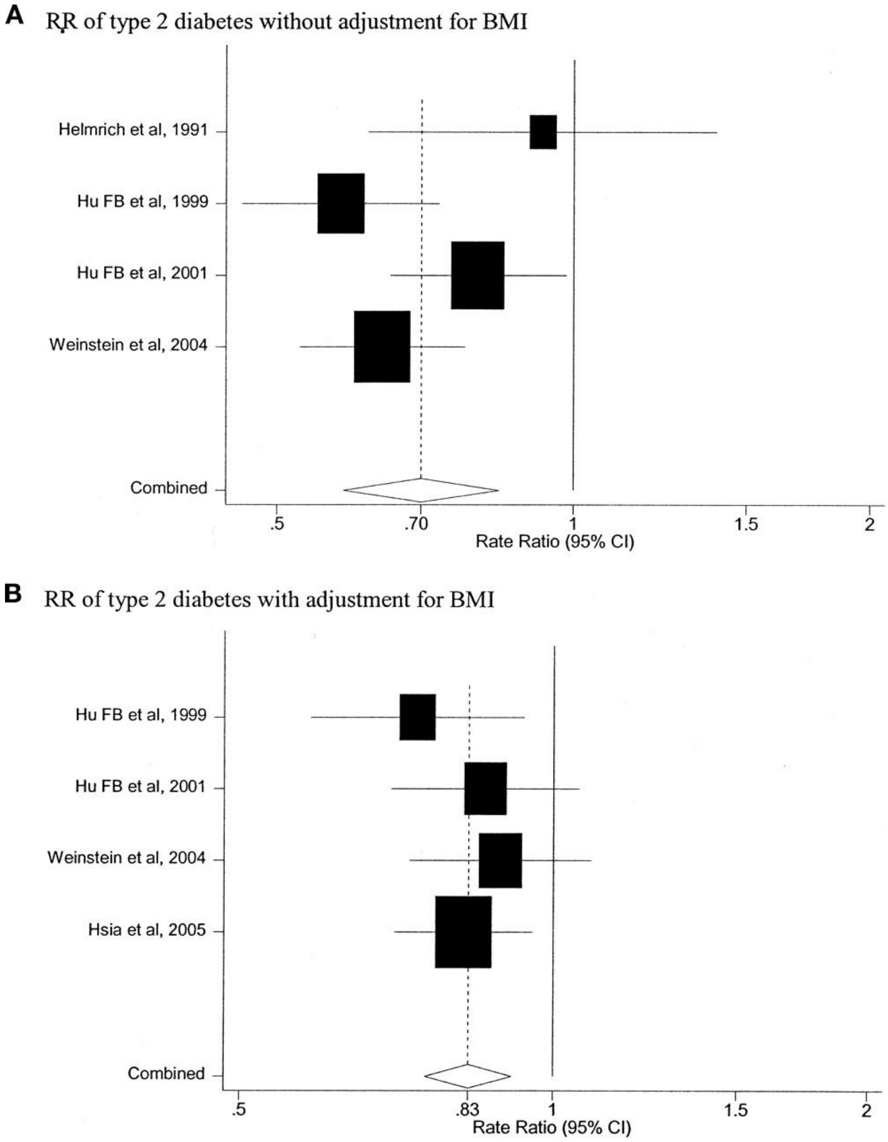
Sattelmair J, Pertman J, Ding EL, Kohl HW, Haskell W, Lee I-M. Dose response between physical activity and risk of coronary heart disease a meta-analysis. Circulation. 2011;124(7):789-95.



Source: Jeon CY,et al. Diabetes Care 2007 [46]

Figure 3: **Review results of total physical activity of moderate intensity and incidence of type 2 diabetes for individual cohort studies(RR) and all studies combined without adjustment for BMI (A) and with adjustment for BMI (B).**

(Seek permission from Diabetes care ***Insert after permission(figure 1 a and b) anf figure 2 a and B) from review article Jeon at al, Diabetes careVol 30, No 3, March 2007)***



Source: Jeon CY,et al. Diabetes Care 2007 [46]

Figure 4: RRs for walking and incidence of type 2 diabetes for individual cohort studies and all studies combined without adjustment for BMI (A) and with adjustment for BMI (B).

*(Seek permission from Diabetes care **Insert after permission(figure 1 a and b) anf figure 2 a and B) from review article Jeon at al, Diabetes careVol 30, No 3, March 2007)***

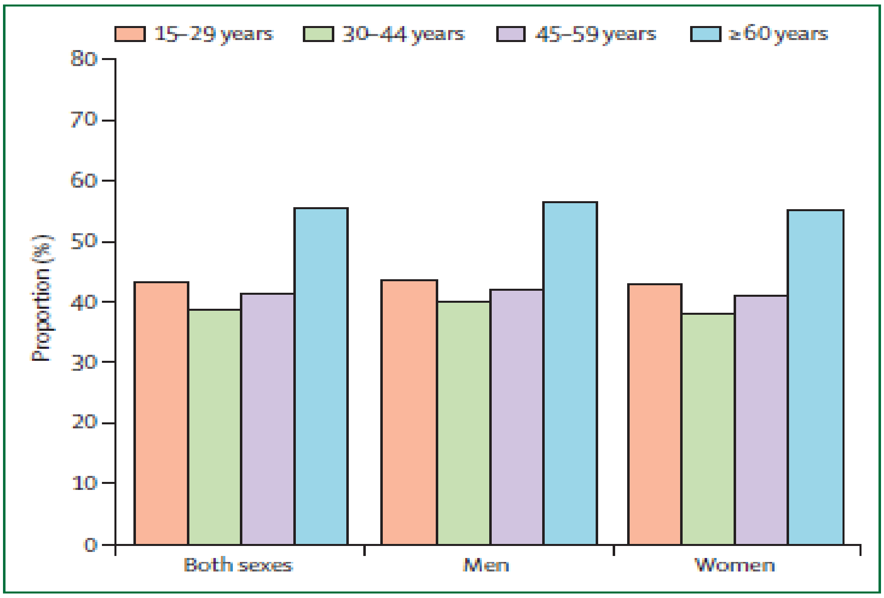


Figure 5. **Global estimates of the proportion of self-reported time spent sitting for 4 or more hours a day in adults by age and sex.**

Source: Hallal et al., (2012)

Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. The lancet. 2012;380(9838):247-57.

Figure 6: Agita São Paulo mascot: the Half-Hour Woman

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Online __.3 Summary of results on direct costs of inactivity from 18 studies between 1980-2014

Country	Author	Year of source data	Prevalence of Inactivity+	National *direct* costs of inactivity to health care^/ (in national Currency)	Percentage of Health care costs attributable to inactivity	% of all cause mortality attributable to Inactivity	DALYS	Annual Costs per inactive person in 2010 US$++
Holland	Rejnen and Velthuijsen, 1989	1983	Not available	-	1.0%	-	-	56
USA	Pratt et al., 2000	1987	43%	US$ 29.2 billion /yr	-	-	-	1412
Holland	Stam et al, 1996	1990	Not available	Dfl 178 million /yr	1.2%	-	-	48
UK	Nicholl et al., 1994	1991	70%	15-44yrs: £6800 / >44yrs: £304,000 per 10,000 persons		-	-	15-44yrs: 143 >45yrs:114
Australia	Stephenson et al., 2000	1994	44%	AU$ 377.4 million/yr	1.1%	-	-	163
USA	Colditz, 1999	1995	29%	US$ 24 billion/yr	2.4%	-	-	1016
Northern Ireland	Swales, 2000	1998	20%	£0.62 million/yr	-	-	-	-
Canada	Katzmarzyk et al.,	1999	62%	C$ 2.1 billion/yr	2.5%	10.3	-	155

	2000							
Switzerland	Martin et al., 2001	1999	37%	SFr 1.6 billion/yr		-	-	637
Canada	Katzmarzyk & Janssen, 2004	2001	54%	C$ 1.6 billion/yr	2.6	-	-	90
Brazil (State of Sao Paulo)	Matsudo et al., 2002	2000	32%	R$ 86 million/yr	3.3	-	-	-
South Africa	Joubert et al., 2007	2000	46%	-	-	3.3	1.1	-
Columbia (City of Bogota)	Lobelo et al., 2006	2002	53%	₽15 million/yr	2.5	-	-	-
UK	Allender et al., 2007	2002-03	17%	£1.06 billion/yr	1.5	3.1	3.0%*	32
UK	Scarborough et al., 2011	2006-07	17%	£0.9 billion/yr	1.2	-	-	-
China	Zhang & Chaaban, 2012	2007	31%	US$3.5 billion/yr	15.7	-	-	-
Czech Republic	Maresova, 2014	2008	5%	Kc 700 million /yr (~€29million)	0.4	2.3	1.2	-
World average[#]	WHO, 2004	2004	31%	-	-	5.5%	2.1%	-

^ all costs given in the year of data unless otherwise indicated

++ Data on direct costs per inactive person calculated by and reported in Pratt et al., 2014 and used year 2010 US$

*data for WHO EUR A region in 2002

+ not all countries defined and measured physical inactivity using exactly the same method

world prevalence estimates from Global Burden of Disease project 2002 (ref 2002 report) updated for 2004

Reference List for Table 1 – requires completion and ordering if this is to be used

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