Chapter 5

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 sit for increasingly long hours at computers, and emails 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 and others 2013; Barnett and others 2008; Bhurosy and Jeewon 2014; Church and others 2011; Hallal and others 2014; Lozano and others 2012; Ng, Norton, and Popkin 2009; Ng and Popkin 2012).

In 2014, two of every three deaths globally—38 million total—were due to noncommunicable diseases (NCDs) (WHO 2014a). 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, and elevated blood pressure and blood glucose levels, all of which heighten the risk of developing cardiometabolic diseases (WHO 2010a).

Physical activity includes different types of activities that can be done in different types of settings, including sports, recreation, play, and transport-related walking and cycling, as well as general movement undertaken as part of daily living, such as shopping, cleaning, or climbing stairs (box 5.1). Physical activities may be undertaken with different degrees of effort and for different durations. Because of this breadth in type, duration, frequency, and even location, measuring, monitoring, and understanding physical activity is complex. Nevertheless, a significant body of knowledge has accumulated on physical activity, its role in primary and secondary prevention of leading NCDs (Physical Activity Guidelines Advisory Committee 2008a), and the causes of participation and nonparticipation in different populations. This evidence forms a strong base for informing current practice and policy in health care and other fields of public policy.

This chapter provides an overview of the 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 the burden of disease attributable to inactivity. It then provides an overview of the epidemiological evidence on the protective effects of physical activity and emerging evidence on the risks of sitting and sedentary activities, dubbed the new smoking (Berry 2013); summarizes the available evidence on the cost of physical inactivity to the health sector; and presents the most promising policy and

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program actions across seven key settings to increase population-level physical activity and, where available, evidence on their cost-effectiveness. It concludes by reviewing the opportunities for action through global, regional, and national policy initiatives and by identifying some of the challenges and barriers to implementation.

Box 5.1

Definition of Physical Activity

Physical activity can incorporate a wide range of lifestyle, sport, and exercise activities (Caspersen, Powell, and Christenson 1985; WHO 2015).

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.

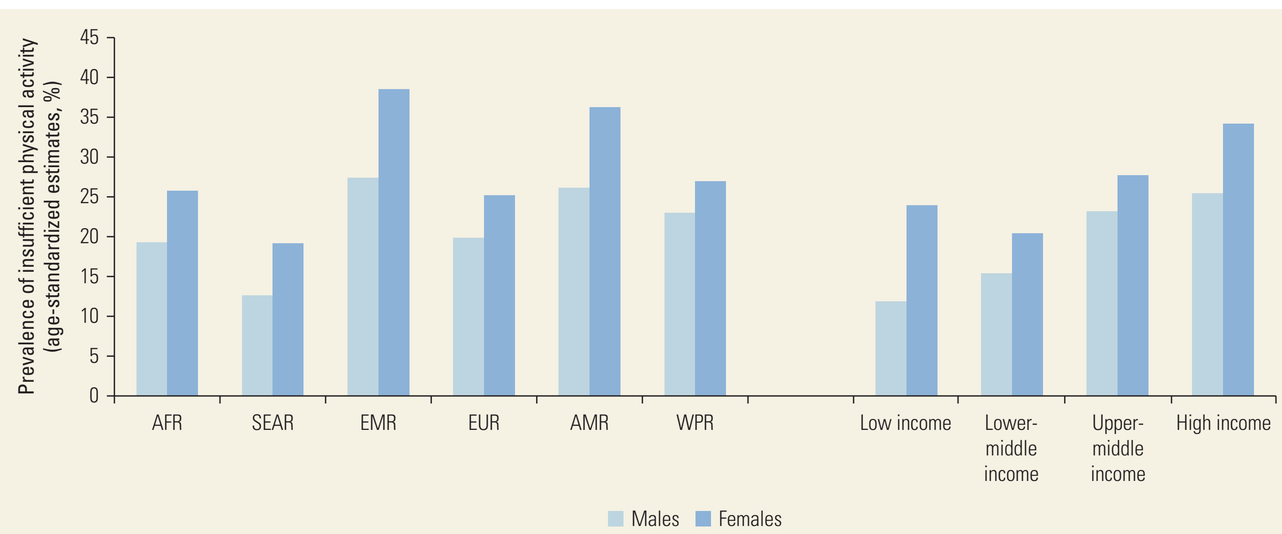
For adults, physical activity includes recreational or leisure-time physical activity, active transport (walking or cycling), work-related activity, household chores, play, games, sports, or planned exercise such as fitness classes.

PREVALENCE AND BURDEN OF PHYSICAL INACTIVITY

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 (WHO 2014a). Gender differences are notable in many countries. Globally, men, in general, are more active than women (prevalence of inactivity globally of 20 percent in men and 27 percent in women). Regional differences are also notable, with proportions of insufficiently active adults ranging from 17 percent in South-East Asia to about 36 percent in the Americas and 38 percent in the Eastern Mediterranean (WHO 2014a) (figure 5.1).

A concerning trend is that levels of inactivity increase with economic development. Adults are less active in high-income countries (HICs) than in low- and middle-income countries (LMICs), a pattern suggesting that inactivity will rise as middle-income countries develop economically. For example, evidence indicates that, in India, urban populations are less active than rural populations (Gupta and others 2008); this is due, in part, to rapid globalization and increasing mechanization leading to less occupational activity and, when coupled with increased affluence, an increase in the use of motor vehicles for transport. These societal changes are well underway in many LMICs; without mitigation,

Figure 5.1 Age-Standardized Prevalence of Insufficient Physical Activity in Adults, by Gender and WHO Regions and World Bank Income Groups, 2014



Source: WHO 2014a.
Note: AFR = African Region, AMR = Region of the Americas; SEAR = South-East Asia Region; EUR = European Region; EMR = Eastern Mediterranean Region; WHO = World Health Organization; WPR = Western Pacific Region.

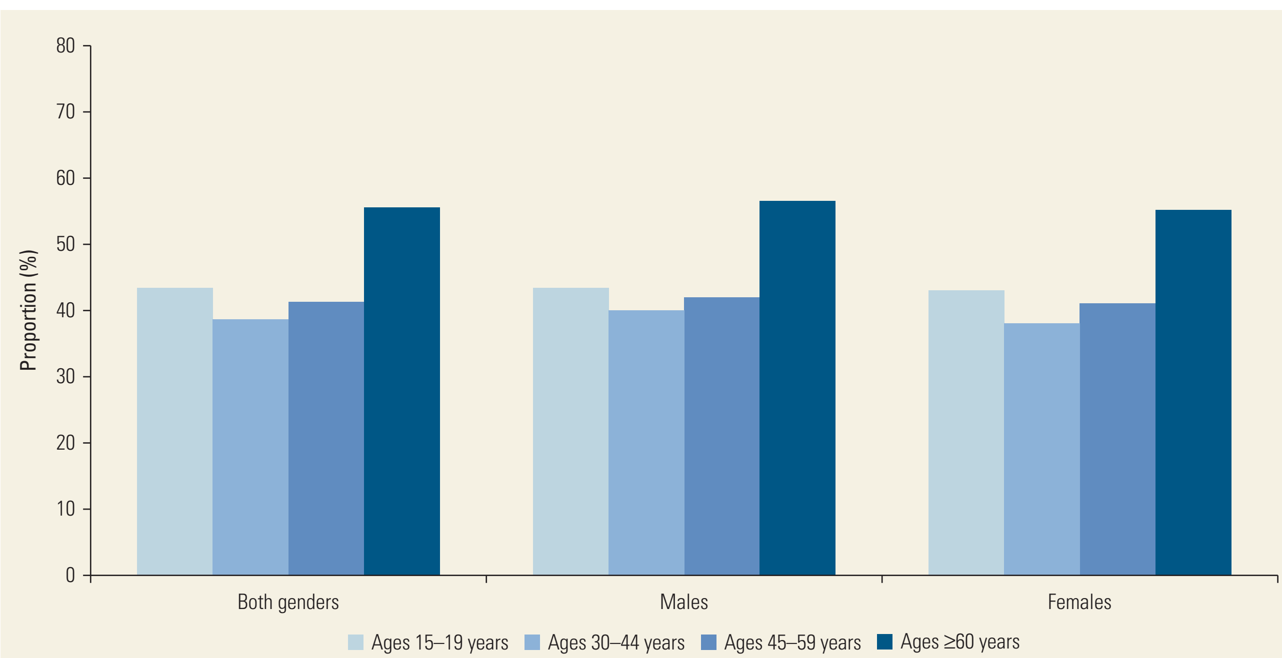
they will likely lead to further decreases in levels of physical activity.

Considerable progress has been made in population-level monitoring of physical inactivity since 2004. In 2000, fewer than 50 countries had any population-level data on physical activity, and many of these were of poor quality and limited reliability (Bull and others 2004). Following the development of the International Physical Activity Questionnaire (Craig and others 2003) and the Global Physical Activity Questionnaire (Armstrong and Bull 2006), many countries began monitoring physical activity, with more than 140 countries reporting population data on physical activity in 2014 (WHO 2014a). These data enable comparisons to be made within and between countries. Furthermore, a growing number of countries have established or committed to establishing surveillance systems for monitoring physical activity to track trends within and between subpopulations and countries.

Less progress has been made in the population-level assessment of physical activity in young people. Few countries have surveillance systems covering ages 5–18 years. Some countries have participated in the Global School-Based Student Health Survey, a large, well-established survey that includes items on physical activity (WHO 2016). However, the survey only covers ages 11–17 years and only reports the proportion not meeting the minimum recommended 60 minutes of moderate-to-vigorous activity per day. These data show that more than 75 percent of adolescents do not meet the global recommendation and that adolescent girls are less active than adolescent boys (Guthold and others 2010; WHO 2010b). The use of objective measures for assessing physical activity in children is preferred and strongly recommended given the complexities of having this age group recall their physical activity behaviors (Wijndaele and others 2015).

Time spent in sedentary (sitting) behaviors is emerging as an independent risk for cardiometabolic disease. Self-reported measures of sedentary behaviors were included in both the International Physical Activity Questionnaire and the Global Physical Activity Questionnaire and provide some of the first population data on prevalence (Hallal and others 2012). Less than half (41 percent) of the adult population globally spends more than four hours a day sitting (figure 5.2). Notably, older adults (older than age 60 years) are more sedentary than younger adults, but the data show little difference by gender. There are, however, 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). These data may underestimate how much populations sit because self-reported measures are poorly suited to measuring time spent in diverse sedentary behaviors across a day.

Figure 5.2 Proportion of Individuals Reporting Sitting for Four or More Hours a Day



Source: Hallal and others 2012.

Increasing levels of inactivity in both HICs and LMICs is cause for concern (Barnett and others 2008; Bhurosy and Jeewon 2014; Hallal and others 2014; Ng, Norton, and Popkin 2009). In the United States, studies have demonstrated an 8 percent to 10 percent decline in occupation-related and 3 percent to 42 percent decline in household-related physical activity during the past four decades (Church and others 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. In these four countries, energy expenditure related to physical activity is expected to decline about 50 percent over four decades. It is therefore necessary to identify and intervene with effective mitigating strategies that provide safe and equitable opportunities for physical activity.

Physical inactivity causes an estimated 9 percent of premature mortality from all causes, or between 3.1 million (Lim and others 2013) and 5.3 million (Lee and others 2012) premature deaths worldwide in 2010. Inactivity accounts for 6 percent of coronary artery disease, 7 percent of type 2 diabetes, 10 percent of breast cancers, and 10 percent of colon cancers (Lee and others 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). These estimates are viewed as conservative because of the limitations of using self-reported measures of exposure.

PHYSICAL INACTIVITY AND CARDIOMETABOLIC RISK

The value of physical activity has long been recognized (Agarwal 2012; Kokkinos 2012), but during the past 60 years scientists have intensified efforts to measure and specify the optimal type, frequency, and duration of physical activity required for different health benefits. The 1996 landmark report by the U.S. Surgeon General, *Physical Activity and Health*, shifted the focus away from training regimes involving shorter bouts of high-intensity exercise and toward the benefits of accumulating regular, sustained amounts of moderate-intensity activity, such as walking (U.S. 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 and others 1995; U.S. Department of Health and Human Services 1996). The recommended minimum threshold of physical activity reflected the curvilinear dose-response relationship identified in epidemiological studies.

More recent reviews confirm that physical activity has a wide range of benefits, including reducing all-cause mortality risk, preventing cardiovascular disease (CVD) and diabetes, improving lipid levels, lowering hypertension, reducing the risks of breast and colon cancer, and improving functional status (Aune and others 2015; Physical Activity Guidelines Advisory Committee 2008b; World Cancer Research Fund 2007). Evidence from epidemiological and clinical studies has identified positive neurological health outcomes showing that physical activity can improve cognition in people without dementia, reduce the incidence of dementia, and improve health among people with dementia (Blondell, Hammersley-Mather, and Veerman 2014).

The following sections provide a brief overview of scientific findings on the relationship between physical activity and specific cardiometabolic health outcomes, including heart disease, stroke, and diabetes, as well as selected key metabolic risk factors.

Physical Activity and Coronary Heart Disease

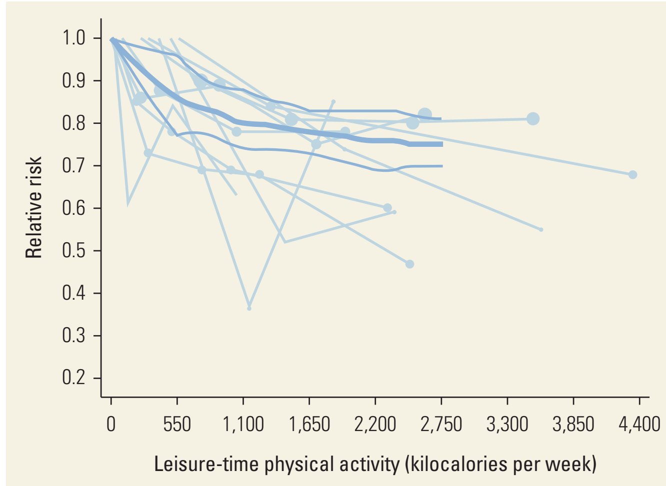
Regular moderate- or vigorous-intensity physical activity, especially leisure-time physical activity, significantly lowers mortality from coronary heart disease (CHD) (Karjalainen and others 2015; Kodama and others 2009; Lee and others 2012). In a meta-analysis of epidemiological studies investigating 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 (Sattelmair and others 2011). 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 and others 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 5.3). These results are consistent with the systematic review–level evidence (Physical Activity Guidelines Advisory Committee 2008b) and recent consensus statements (Swift and others 2013), which concluded that there is a strong inverse relationship between the amount of habitual physical activity performed and CHD morbidity or mortality in men and women at middle age or older. Furthermore, these results may underestimate risk reduction because multivariate models in many studies include adjustments for hypertension, dyslipidemia, and glucose tolerance, conditions that may represent biological intermediates in the causal pathway (Physical Activity Guidelines Advisory Committee 2008b).

Of particular importance is that the protective effects of physical activity (as measured by cardiorespiratory fitness) on CVD and CHD are independent of levels of overweight and obesity, as measured by body mass index (BMI) (Barry and others 2014; Blair and others 1989; Kodama and others 2009). A meta-analysis confirmed that fit individuals who are overweight or obese are not automatically at higher risk for all-cause mortality and that low-fit individuals have twice the risk of death regardless of BMI (Barry and others 2014). Such findings are important for all individuals, including those unable to lose weight or maintain weight loss, because significant health benefits can be attained by maintaining a moderate level of cardiorespiratory fitness through regular physical activity (Barry and others 2014).

To date, few studies have assessed the potential for differential risk reduction from physical activity undertaken in different domains, with the majority of studies assessing either total physical activity or only leisure-time activity. A meta-analysis of 21 prospective cohort studies assessed the separate protective effects of occupation and leisure-time physical activity on CHD and stroke outcomes (Li and Siegrist 2012). This analysis of 650,000 adults (with 20,000 incident cases) showed that both moderate and high levels of leisure-time activity and moderate levels of occupational physical activity have protective effects in both men and women. The pooled analyses (men and women) showed an overall 18 percent reduction in risk of CVD (relative risk [RR] 0.82, 95 percent confidence interval [CI] 0.67–0.88, $p < 0.001$) compared with the reference group with low leisure-time physical activity, while a high level of leisure-time physical activity reduced the overall risk of CVD by 27 percent (RR 0.73, 95 percent CI 0.68–0.78, $p < 0.001$) (Li and Siegrist 2012).

Exercise-based cardiac rehabilitation is the cornerstone of secondary prevention of CVD and should include baseline patient assessment, nutritional and physical activity counseling, and exercise training (Balady and others 2007). Results from a recent Cochrane Review of 63 studies, with median follow-up of 12 months, showed a reduction in cardiovascular mortality (RR 0.74, 95 percent CI 0.64–0.86) and risk of hospital admissions (RR 0.82, 95 percent CI 0.70–0.96) (Anderson and others 2016). Furthermore, the majority of studies (14 of 20) showed higher levels of health-related quality of life in one or more domains following exercise-based cardiac rehabilitation compared with control subjects.

Figure 5.3 Dose-Response between Leisure-Time Physical Activity and Risk of Coronary Heart Disease



Source: Sattelmair and others 2011.

Participation in exercise-based cardiac rehabilitation programs has also been found to be associated with reduced angina symptoms and depression, improved exercise capacity, and enhanced health-related quality of life (Taylor and others 2004).

Overall, strong evidence supports the role of physical activity in primary and secondary prevention of CHD. Strategies to integrate physical activity counseling and referral within care pathways for patients with, or at risk of, CHD are needed (Swift and others 2013).

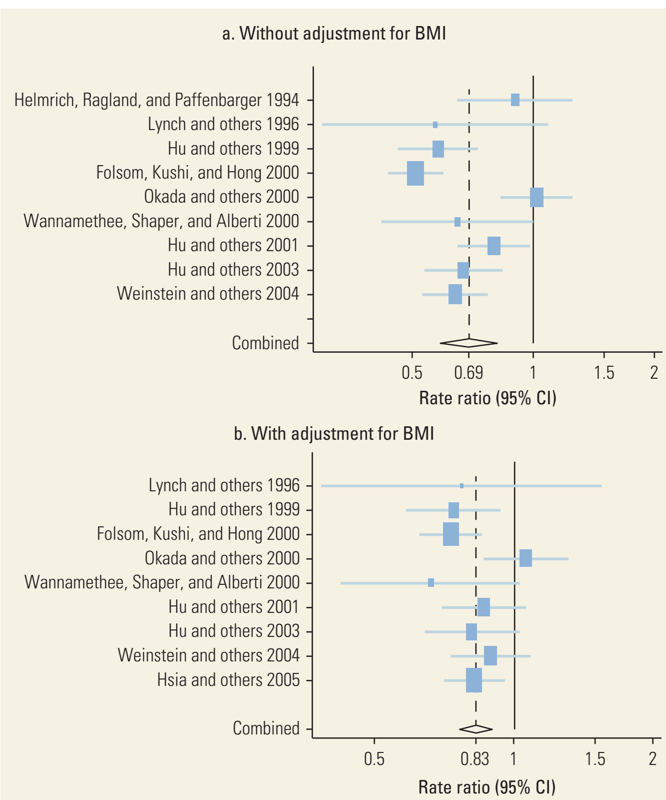
Physical Activity and Stroke

Evidence regarding the protective effect of physical activity on stroke has shown mixed results, with some studies showing positive, inverse, and even U-shaped associations (Diep and others 2010). Yet, on balance, systematic review–level evidence does conclude that physical activity has a favorable impact on stroke end points. In 2008 a systematic review conducted for the U.S. Physical Activity Guidelines concluded that physical activity can reduce the risk of both ischemic and hemorrhagic stroke, although noting that the data on stroke subtypes were limited (Physical Activity Guidelines Advisory Committee 2008b). Diep and others (2010) conducted a meta-analysis of 13 cohort studies and found that, compared with low levels of physical activity, moderate levels of activity were associated with an 11 percent reduction in the risk of stroke (RR 0.89, 95 percent CI 0.86–0.93, $p < 0.01$), and high levels of activity were associated with a 19 percent reduction (RR 0.81, 95 percent CI 0.77–0.84, $p < 0.01$).

Although similar results were seen in men and women for higher levels of activity, only in men was there a significant association between moderate levels of activity and reduced risk of stroke (Diep and others 2010). This review suggested that high levels of activity may be required in women, but it did not specify what that dose (intensity, frequency, or duration) might be.

Another review involving 21 studies assessed the associations between occupation and leisure-time physical activity and stroke (Li and Siegrist 2012) and reported that both types of activity were protective in both men and women. Although more research is needed to understand the causal pathways and to confirm the amount of physical activity required, there is a general consensus that participation in physical activity consistent with global recommendations for adults and older adults should be stressed as part of an overall stroke prevention strategy (Howard and McDonnell 2015).

Figure 5.4 Moderate-Intensity Physical Activity and Rate Ratio of Type 2 Diabetes for Individual Cohort Studies and All Studies Combined



Source: Jeon and others 2007.
Note: BMI = body mass index; CI = confidence interval.

Physical Activity and Type 2 Diabetes

Physical activity has a strong and inverse association with type 2 diabetes. In both cohort studies and randomized controlled intervention trials, physical activity has been shown to lower the overall risk for type 2 diabetes between 30 percent and 60 percent (Ishida, Ito, and Murakami 2005; Knowler and others 2002; Li and others 2008; Ramachandran and others 2006). A systematic review (Jeon and others 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 than in those who had a sedentary lifestyle (figure 5.4). The results remained significant even after adjusting for BMI. Among these studies, five investigated the role of walking (Helmrich, Ragland, and Paffenbarger 1994; Hu and others 1999; Hu and others 2001; Hu and others 2003; Weinstein and others 2004); results showed that regular brisk walking of 2.5 hours per week decreased the risk of diabetes by 30 percent compared with no walking (figure 5.5). These results included adjustments for age, family history, educational status, smoking, alcohol, cholesterol level, BMI, and, in some instances, waist-to-hip ratio (Lindstrom and others 2006). These are important findings given the popularity and ease of walking as a form of daily physical activity and thus support potential population-based walking interventions targeting middle- and older-age adults.

Physical activity is also beneficial for patients with impaired glucose tolerance (IGT) (Mohan and others 2006; Ramachandran and others 2006). Two landmark clinical trials—the Diabetes Prevention Program (Knowler and others 2002) and the Finnish Diabetes Prevention Trial (Folsom, Kushi, and Hong 2000; Weinstein and others 2004)—established that physical activity combined with dietary modulation can lower the risk of diabetes in individuals with impaired fasting glucose or with IGT. Some studies have shown that these beneficial effects can persist for 10 years or more (Perreault and others 2009; Weinstein and others 2004).

Figueira and others (2014) conducted a meta-analysis of 30 randomized controlled clinical trials of structured training programs (2,217 patients) and 21 studies of the effectiveness of providing advice on physical activity (7,323 patients). They assessed the effect on blood pressure in patients with type 2 diabetes of different structured exercise programs (aerobic, resistance, or combined) compared with advice alone. The results showed that structured exercise was associated with significant reductions in the weighted mean difference of −4.22 millimeter of mercury (mmHg, a measure of pressure) (95 percent CI −5.89 to −2.56) for systolic and −2.07 mmHg (95 percent CI −3.03 to −1.11) for diastolic blood pressure versus controls. Higher levels of structured exercise (more than 150 minutes per week) were associated with even greater reductions in blood pressure (Figueira and others 2014).

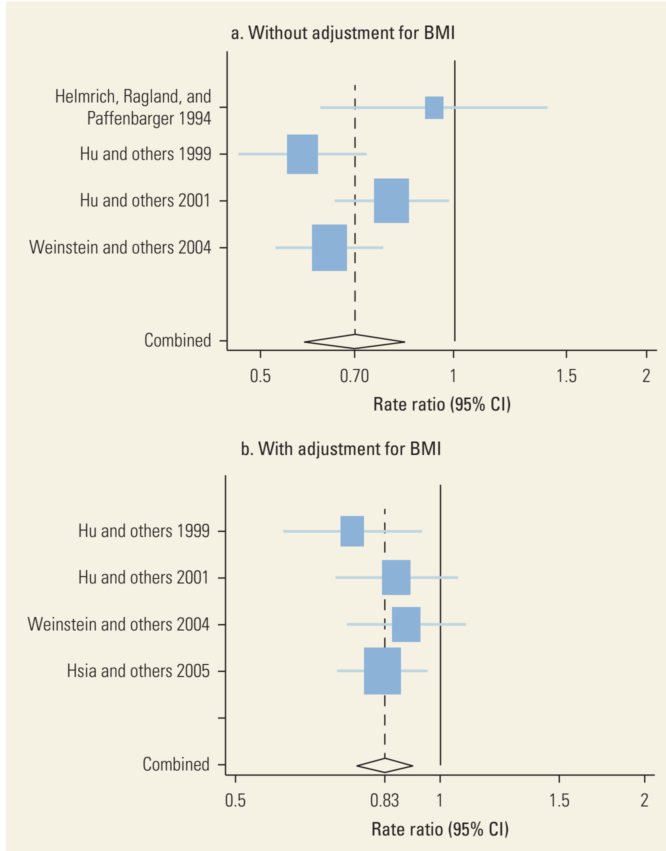
These studies provide strong evidence that behavioral interventions aimed at encouraging regular physical activity can be effective for tackling diabetes at the population level, including in LMICs (American Diabetes Association 2014; Goenka 2008; Goenka and others 2009). More than 77 percent of the 316 million people with IGT worldwide live in LMICs and are ages 20–39 years (Li and others 2008). Given that the conversion to diabetes is more rapid in India and South-East Asian countries than globally (Mohan and others 2006; Ramachandran and others 2006), the assessment of and referral to physical activity programs should be integrated into primary health care pathways for patients at risk of diabetes (Adler and others 2000; Alberti, Zimmet, and Shaw 2007; Chobanian and others 2003; Stamler and others 1993; U.K. Prospective Diabetes Study Group 1998).

Physical Activity and Cardiometabolic Disease Risk Factors

Physical activity has been shown to be effective in improving key risk factors of cardiometabolic disease. Regular physical activity can decrease systolic and diastolic blood pressure (Fagard 2005), with evidence supporting the benefits achieved from moderate-intensity activity (such as walking) as well as vigorous activity. Results from the Coronary Artery Risk Development in Young Adults Study suggest that approximately 34 percent of hypertension could be prevented if adults would increase their physical activity and fitness (Carnethon and others 2010; Pereira and others 1999). Adjustment for fasting insulin level and waist circumference attenuated the results, indicating that the association between activity and incident hypertension may be mediated by obesity and the metabolic syndrome. However, both insulin levels and waist circumference are part of the causal pathway, and adjusting for them therefore results in overadjustment.

In a study of 7,400 older adults ages 45–65 years (Atherosclerosis Risk in Communities), white men in the highest quartile of the sport and leisure indexes had significant reductions in the odds of developing hypertension of 23 percent and 34 percent, respectively, compared with men in the lowest quartiles (Pereira and others 1999). A similar magnitude of risk reduction was

Figure 5.5 Walking and Rate Ratio of Type 2 Diabetes for Individual Cohort Studies and All Studies Combined



Source: Jeon and others 2007.
Note: BMI = body mass index; CI = confidence interval.

reported in the Henry Ford Exercise Testing Project, which observed the associations across strata of age, gender, race, obesity, resting blood pressure, and diabetes (Juraschek and others 2014).

Physical activity can directly and indirectly reduce the effects of excess cholesterol and other atherosclerotic agents (Durstine, Haskell, and Holloszy 1994; Farrell, Finley, and Grundy 2012; Pedersen and Saltin 2015). A review article of 13 studies and two review articles concluded that both aerobic and resistance exercise and the combination of aerobic and resistance training have an impact on cholesterol levels and blood lipids (Mann, Beedie, and Jimenez 2014). Participation in both moderate- and higher-intensity physical activity was shown to provide beneficial improvements in cholesterol levels, specifically increasing good (high-density lipoprotein) cholesterol, while maintaining and theoretically offsetting increases in bad (low-density lipoprotein) cholesterol and triglycerides (Kokkinos 2012; Mann, Beedie, and Jimenez 2014).

Regular physical activity in overweight and obese adults can have positive effects on waist circumference and body weight, both of which are risk factors for cardiometabolic disease. Results from a Cochrane Review show that physical activity combined with a restricted diet and dietary counseling is effective and more effective than physical activity alone (Shaw and others 2006). Physical training combined with a restricted diet and dietary counseling reduces body weight slightly, but significantly more than a restricted diet or dietary counseling alone (Shaw and others 2006). Studies of physical training without dietary change showed that high-intensity physical training reduced body weight more than low-intensity physical training (Shaw and others 2006). These results are consistent with other meta-analyses (Johns and others 2014; Wu and others 2009).

Sedentary Activity and Sitting: An Emerging Risk Factor

Sedentary behavior is emerging as a new and potentially independent risk factor for cardiometabolic disease (Owen and others 2010). Sedentary behavior is distinct from physical activity and comprises very low-level energy expenditure activities such as sitting or lying down. There is now good evidence that time spent in prolonged, particularly uninterrupted, "sitting" is a risk factor for cardiovascular and associated comorbidities, 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 and others 2012; Dunstan and others 2010; Dunstan, Thorp, and Healy 2011; Healy and others 2008).

Patel and others (2010) assessed the relationship between sitting and physical activity and total mortality in a large prospective study of U.S. adults. Results showed time spent sitting (six or more versus fewer than three hours a day) was associated with mortality in both women (RR 1.34, 95 percent CI 1.25–1.44) and men (RR 1.17, 95 percent CI 1.11–1.24), after adjustment for smoking, BMI, and other factors. These associations were strongest for CVD mortality. 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 (Dunstan and others 2012; Healy and others 2008; Larsen and others 2014).

Other studies using objective measures of sedentary time (such as accelerometers) have also reported increased risks associated with sedentary behavior for long durations and the benefits of breaking up sitting time by brief periods of standing or light activity (Chau and others 2013; Parsons and others 2016). Collectively this emerging body of evidence suggests that public health action is warranted both to increase physical activity and to reduce time spent sitting. Although global guidelines on how much sitting is too much are not yet available, some countries have already reviewed the evidence and developed national recommendations, particularly for children and youth (Tremblay and others 2011).

Summary of the Evidence

Physical activity has well-established benefits for the prevention and management of cardiometabolic diseases. In addition, regular physical activity can provide 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 and others 2009), preventing falls and promoting independent living in older adults (Sherrington and others 2008), and preventing osteoporosis by generating and maintaining peak bone mass (Bielemann, Martinez-Mesa, and Gigante 2014; Kemmler and others 2015). Regular participation in physical activity is important across the life span. For young children, regular active play and active recreation promote healthy growth and development, fitness, and healthy weight and can improve cognitive development and academic performance (Singh and others 2012). Physical activity is independently associated with prevention of CHD, stroke, and diabetes and can modify other metabolic risk factors such as hypertension, hyperlipidemia, and overweight and obesity. Walking and other forms of moderate-intensity physical activity can provide protective effects, and emerging evidence now suggests the importance of efforts to reduce time spent in prolonged sedentary behaviors for optimal health outcomes.

ECONOMIC COSTS OF PHYSICAL INACTIVITY

Before the 1990s, virtually no published data addressing the costs of inactivity were available. 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 countries, mostly HICs.

Online annex 5A 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.

Pratt and others (2014) synthesized 11 published estimates from six HICs and, despite heterogeneity between studies and health systems, found consistent results attributing between 1.0 percent and 2.6 percent of total health care costs (for the selected health outcomes) to inactivity. Higher estimates were explained by the inclusion of additional health outcomes over and above CHD, stroke, diabetes, and cancer—for example, osteoporosis, musculoskeletal conditions (that is, 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. These estimates may appear high, but given the substantial evidence on the role of physical activity in the prevention and treatment of other health outcomes, estimates that exclude these conditions are generally viewed as conservative. Although desirable, inclusion of these other conditions is frequently hampered by a lack of reliable data, especially in LMICs.

Studies from LMICs, such as Brazil (São Paulo) and Colombia (Bogotá), provide similar estimates of total direct health care costs from physical inactivity (3.3 percent and 2.5 percent, respectively). In Eastern Europe, an analysis from the Czech Republic 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, 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 2001 and projected that these costs will reach 8.7 percent of total health care costs by 2025.

Most of the economic evidence to date has estimated direct health care costs. However, the *indirect* costs of inactivity include the value of economic output 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 (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) was direct costs and Can$3.7 billion (US$2.8 billion) was indirect costs.

Another example is from the United Kingdom, where Game Plan, the national policy on sports and physical activity, reported that inactivity cost almost £2 billion (US$2.8 billion) a year, of which £0.3 billion (US$0.4 billion) was direct costs to the national health system, £0.8 billion (US$1.1 billion) was due to absence from work, and £0.8 billion (US$1.1 billion) was due to premature mortality (Department of Culture, Media, and Sports 2002; Scarborough and others 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, although some challenge these estimates because of the lack of transparency of methods (Allender and others 2007). Nonetheless, Game Plan takes a more sophisticated approach to incorporating all costs and benefits of inactivity in a model.

Several countries have undertaken economic modeling of change in level of activity. In Northern Ireland, reducing inactivity from 20 percent 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 older than age 75 years. In New Zealand, reducing inactivity from 31 percent to 21 percent could potentially save $NZ 48 (US$32 million) a year, while in Australia a 10 percent reduction could save 25,000 of the 174,000 attributable disability-adjusted life years and save the health care sector $A 96 million (US$72.6 million)—about 14 percent of annual health sector costs (Cadilhac and others 2011).

To date the economic arguments for savings in health care costs are not used extensively, at least at the global level, which may reflect the heterogeneity of current evidence and suggests 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 efforts to develop extensive global, regional, and national datasets on the burden of disease are providing a strong foundation and good research opportunities to support the rapid maturation of this field over the next three to five years.

INTERVENTIONS TO INCREASE POPULATION-LEVEL PHYSICAL ACTIVITY

Demand is growing for clear policy direction on how to increase population-level participation in physical activity supported by robust evidence on the effectiveness of strategies that are transferable to diverse settings and contexts globally. To date, research undertaken in HICs (notably Australia, Europe, and North America) dominates the published literature; however, evidence from LMICs is accumulating and now includes some systematic reviews (Barbosa Filho and others 2016; Hoehner and others 2013).

National governments have periodically reviewed the evidence to produce guidance for policy development; notable examples are in the United Kingdom and the United States (see online annex 5B for references). However, to date few globally relevant resources provide easily accessible, evidence-based information with wider applicability on what works to increase physical activity. To fill this gap, the Global Advocacy for Physical Activity Initiative developed a "blueprint" for a settings-based, population approach to increasing physical activity (GAPA 2012). The resulting document, "NCD Prevention: Seven Investments That Work for Physical Activity," provides a framework for national action that is applicable to all countries:

- *Whole-of-school programs,* including regular, quality opportunities for physical education and activity for all children before, during, and after the school day
- *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
- *Transport and urban design policies, regulations, and infrastructure* that prioritize and support safe, accessible walking and cycling; use of public transport; and safe access to recreational and sporting opportunities
- *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.

The latest evidence and best practice support the importance of each of these seven areas. Schools and primary health care are well-established settings for primary prevention and health promotion, including physical activity. Community-wide public education strategies also can and should address physical inactivity. Recent evidence has reinforced the importance of transport and urban design in shaping activity levels because these sectors provide the supportive infrastructure and environments for physical activity, such as on- and off-road cycle paths, footpaths and pedestrian networks, sporting and recreational facilities, and public open spaces.

This following sections summarize programs in these settings and identifies key barriers to scaling up action and implementation.

Whole-of-School Programs

Substantial evidence indicates that undertaking whole-of-school programs can promote physical activity. This approach should ensure that physical education takes place regularly and that classes provide opportunities for all students to be highly active (Kemmler and others 2015). Schools should also provide supportive environments, within the limitations of their resources, to support both structured and unstructured play and physical activity by children throughout the school day. Approaches should include promoting of walking and cycling to school, where safe and appropriate, and an enabling policy environment with engagement of parents, teachers, students, and members of surrounding communities (GAPA 2012).

The key principles of a whole-of-school approach have been shown to be effective in high-income as well as resource-constrained contexts, such as in Latin America (Barbosa Filho and others 2016; Ribeiro and others 2010). However, although good examples exist, to date, very few countries have implemented a comprehensive school strategy on a national scale, partially because of competing priorities, inadequate resources, and weak enforcement of the legislative and policy structures.

Primary Health Care

There is a well-established evidence base, albeit largely from HICs, supporting the effectiveness of having health care professionals counsel patients on physical inactivity as part of primary and secondary prevention care pathways. A typical approach includes a brief assessment of patients' level of physical activity as a vital sign for NCD prevention and provision of brief advice by the health care professional with referral to community-based opportunities and programs (Arena, Harrington, and Després 2015). Often called *exercise referral* or *exercise by prescription*, these approaches have been integrated, in varying degrees, into the primary health care systems of countries such as New Zealand and the United Kingdom as well as those of some health care providers in the United States. For example, as described in online annex 5C, New Zealand's Green Prescription has been scaled up to a national level through a partnership between general practitioner groups and the Ministry of Sport and Recreation and with funding from the Ministry of Health (Elley and others 2003). Such initiatives can also be found in Sweden (Kallings and others 2008), the United Kingdom (Boehler and others 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. However, more research is needed to assess the effectiveness and feasibility of this approach in LMICs in which the system and resource context of primary health and other competing priorities present significant challenges.

Public Education Campaigns

Public education through mass media campaigns can provide an effective way to transmit consistent and clear messages about the benefits of physical activity to large populations. It can include paid advertisements and nonpaid news coverage across a variety of media platforms and aim to raise awareness, increase knowledge, shift community norms, and motivate populations to be more active (Cavill and Bauman 2004). Public education campaigns should ideally involve multiple channels (print, audio, and electronic media; outdoor billboards; and posters) as well as new media (text messaging, social networking, and other uses of the Internet) in coordination with other community-based activities to form a comprehensive strategy. Combinations of these approaches, sustained over time (usually years), is most effective, and there are published examples from high- and some middle-income countries of the effectiveness of this approach (Hoehner and others 2013; Leavy and others 2011). Although public education campaigns were identified as a best buy by the World Health Organization (WHO) (2014b), and it is recommended that countries scale up implementation, education strategies alone are insufficient to achieve population-level change in physical activity; coordinated strategies across other settings are needed (Leavy and others 2011).

Transport and Urban Design Policies, Regulations, and Infrastructure

The need for supportive policy, programs, and systems within the transport and urban design sector was highlighted nearly two decades ago (Sallis, Bauman, and Pratt 1998), and there is now an impressive body of evidence reporting the strong and consistent impacts of urban and transport design on levels of physical activity in both HICs and LMICs (Adams and others 2013; Sallis and others 2016). Interventions that provide relevant infrastructure aimed at promoting safe walking and cycling ("active transport") are practical, sustainable ways to increase daily physical activity in whole populations. They also provide benefits to other sectors by reducing traffic congestion, noise and air pollution, and carbon dioxide emissions. Supportive policy frameworks in transport and planning are needed that reorient and reprioritize land use allocation and infrastructure provision to encourage walking, cycling, and public transport. When combined with effective promotional programs, supportive policies can shift the chosen mode of transport away from personal motorized vehicles and toward physical activity (Ogilvie and others 2016).

Such approaches are beginning to gain traction, particularly in cities where the cost of urban sprawl and levels of congestion and pollution have supported a reappraisal of regional, city, and neighborhood urban planning. Cities such as Amsterdam, Copenhagen, and New York as well as Bogotá and Recife provide good examples of how changes in design and infrastructure can lead to significantly higher levels of walking and cycling for short trips and overall physical activity (New York State Government 2010; Paez and others 2015; Pratt, Perez, and others 2015; Pucher, Dill, and Handy 2010). In Bogotá, Colombia (Torres and others 2013), and Recife, Brazil (Reis and others 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 safe and convenient forms of transport for short trips (box 5.2). Robust longitudinal evidence is now available from studies evaluating new urban planning policies that prioritize design elements that support active transport and outdoor recreation (Goodman, Sahlqvist, and Ogilvie 2014; Hooper and others 2015; Ogilvie and others 2016), although more examples, particularly from longitudinal evaluations of city redesign in LMICs, are needed to demonstrate this feasible population-based approach to promoting physical activity (Goenka and others 2007; Goenka and others 2009) (boxes 5.2 and 5.3).

Sports Systems and Programs

Potential synergies exist between sports and the promotion of physical activity given that sports, by definition, involve physical activity. However, sports programs do not necessarily encourage mass participation because they often focus on supporting the talented, encouraging high performance and elite competitions. Yet, population levels of physical activity could be increased through greater engagement with community-based sports programs, particularly those using the Sport for All principles (International Olympic Committee 2014). Building on the universal appeal of sports, a comprehensive and inclusive national sports policy and system should

Box 5.2

Community-Based Programs in Brazil

Academia da Cidade was initiated in the city of Recife, a state capital in northeast Brazil. The program provides free daily physical activity classes in early mornings and late afternoons led by trained physical educators. Restructuring and reengineering of public parks and plazas, often in poor and dangerous neighborhoods, increased provision of safe public spaces in the community for physical activity along with good equipment and supervision. Strong connections with the public primary health care system allowed for easy referrals for prevention and treatment of noncommunicable diseases. Program evaluation showed positive results, and it has been adapted and expanded to more than 400 cities that are delivering community classes and improving infrastructure to support physical activity (Simoes and others 2009).

Agita São Paulo (Move São 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 and others 2002). It focuses on students, workplaces, and the community and applies an ecological model with strategies aimed at addressing the intrapersonal, social, and physical-environment factors that influence physical activity (Matsudo and others 2004). Evaluation showed high levels of program awareness, an increase in physical activity, and reductions in sitting time. Agita São Paulo was led and coordinated by the Studies Center of the Physical Fitness Research Laboratory of São Caetano do Sul.

Key success factors include the following:

- 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
- Strong intersectoral and intrasectoral partnerships involving government, nongovernmental organizations, and the private sector
- Targeting of subpopulations with tailored messages and exploiting cultural links
- Combining permanent actions with large events (for example, Agita Galera involves almost 6 million students from more than 6,000 schools)
- Maximal use of unpaid mass media for promotion
- Capacity building across 17 regional departments of health covering 645 cities.

Box 5.3

Community-Based Programs in Colombia

In Colombia, a number of city programs began in the 1990s, eventually forming a national physical activity network in 2002. In 2008, an intersectoral government commission for physical activity was created, and in 2009, the Congress of Colombia passed a national obesity law that included strategies for improving environments, policies, and programs for physical activity. The National Development Plan 2010–14 included physical activity promotion as a priority, with specific 10-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 physical activity professionals across Colombia to deliver community-based programs modeled on Muévete Bogotá (Gámez and others 2006) and the *ciclovías* of Bogotá, Medellin, and Cali (where it is referred to as open streets programs) (Sarmiento and others 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.

include the provision of sporting opportunities to match the interests, skills, and capabilities of men, women, girls, and boys of all ages. The Sport for All initiative focuses on the democratization of, and mass participation in, sports and recreation with the aim of improving 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, Sport for All programs are usually community based, culturally adapted, and inclusive, and they build on partnerships between local sporting clubs, municipal sports and recreational authorities, and national sports organizations (Cousineau, Collins, and Coopeer 1998; Marlier and others 2015).

One 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 targets hard-to-reach men from low-income communities in Scotland and provides weekly physical activity sessions at a professional soccer club along with nutritional information and follow-up. The results have included significant weight loss; reduction in waist circumference, body fat, and blood pressure; as well as improvements in physical activity compared with the control group (who received information only) (Hunt and others 2014). Furthermore, there has been minimal loss at follow-up, and the approach has been shown to be cost-effective and capable of attracting and retaining men at risk of cardiometabolic diseases (Hunt and others 2014). Sport for All programs can also address gender inequalities (see box 5.4).

Promotion of physical activity is aligned with the United Nations Sport 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 addressing selected health issues. Grassroots Soccer is a well-known initiative typically practiced in low-income settings. It has increased awareness of and lowered the stigma regarding human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS) and contributed significantly to achieving the recommended guidelines for moderate-to-vigorous activity for youth (Fenton, Duda, and Barrett 2014).

Community-Based Programs

Community-based programs are programs run outside of schools and the health care system, including programs offering exercise classes in worksite, faith-based, and other community venues and public spaces. This is a diverse area of research, but it has shown some positive results, particularly in low-income settings. Boxes 5.2 and 5.3 discuss examples of programs run in the community and changes to the use of road infrastrcture to support safe walking and cycling. Other examples of community-based programs include exercise equipment and programs provided in urban parks, often free of charge for community use.

COST-EFFECTIVENESS OF PHYSICAL ACTIVITY INTERVENTIONS

Several reviews provide estimates of the cost-effectiveness of population-level physical activity interventions (Laine and others 2014; Roux and others 2008). Roux and others (2008) conducted a lifetime cost-effectiveness analysis using a societal perspective to estimate the costs, health gains, and cost-effectiveness (dollars per quality-adjusted life year [QALY] gained) of seven public health

Box 5.4

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-on Sustainable Development Goals (United Nations 2015) address gender inequalities, with several targets related to equitable educational environments and opportunities for women and girls.

interventions recommended by the U.S. Guide to Community Preventive Services. The interventions tested were community-wide campaigns; individually adapted health behavior change; social support interventions; and creation or enhancement of access to information on, and opportunities for, physical activity. Each intervention was compared with 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.

Laine and others (2014) developed methods to convert the costs of interventions into costs per person per day in 2012 U.S. dollars and calculated the physical activity results as the metabolic equivalent of task hours (MET-h) gained per person per day. The results showed that population-based interventions such as providing opportunities for biking and cycling were 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), and the use of pedometers (US$0.014 per MET-h) (Laine and others 2014). Interventions that sought to affect the behavior of individuals were the least cost-effective but had the largest effects (Wu and others 2011). In primary care settings, Garrett and others (2011) estimated the cost to move one person to the "active" category at 12 months to be between €331 and €3,673 (between US$369 and US$4,095). The estimated cost-utility varied across nine studies from €348 (US$388) to €86,877 (US$96,865) per QALY.

Further research is needed to assess the cost-effectiveness of different interventions across different settings and resource contexts. Although this research has been called for before (Kohl and others 2012), inadequate progress has been made toward strengthening this evidence base.

GLOBAL PROGRESS IN PUBLIC POLICY

The 2004 Global Strategy on Diet, Physical Activity and Health (WHO 2004) provided consensus on the importance of physical activity for NCD prevention and detailed the recommended national actions required to increase physical activity and decrease sedentary activity globally. The 2011 United Nations Declaration (United Nations 2011) and the 2014 WHO Global Action Plan for the Prevention and Control of NCDs 2013–2020 (WHO 2013) provide an updated framework for physical activity in national NCD policies. The NCD monitoring and evaluation framework requested by the United Nations and led by the WHO resulted in the first global target on physical activity—namely, to reduce inactivity by 10 percent by 2025 (WHO 2013). Collectively, these documents provide the global policy framework for population-based action on physical activity within all countries.

Although many Northern and Western European countries began by developing national policies on physical activity in the late 1990s, the global target and United Nations Declaration provide a new stimulus to all countries, particularly to LMICs. Recent reviews of current national policy approaches have identified areas that need strengthening (Bull and others 2014; Bull and others 2015; Daugbjerg and others 2009). Policy documents often state no measurable, time-bound targets for physical activity; many countries have no systematic population surveillance system in place to track trends; policy implementation is weak and inadequately resourced; and relevant sectors have limited capacity (Bull and Bauman 2011).

In LMICs, progress on national physical activity policies and actions has been much slower, although global policy frameworks have stimulated a notable increase in recent years. Indeed, the proportion of countries with policies on physical activity has risen from 29 percent in 2005 to 73 percent in 2010 and to 80 percent in 2013 (Sallis and others 2016; WHO 2015). However, ensuring and monitoring policy implementation are now a priority area. Although 80 percent of countries reported policies on physical activity in 2013, only 56 percent of these policies were operational—that is, the policy was "active and funded" (WHO 2015). This highlights a significant gap in country capacity to implement actions on physical activity, even when a policy priority is established.

Other civil society reporting systems (Pratt, Ramirez, and others 2015; Tremblay and others 2014) are providing useful data and reports assessing individual country progress. Such report cards vary in their content, level of detail, and intended audience. Other tools support countries undertaking comprehensive situational analyses of physical activity policy. Use of the Policy Audit Tool (Bull and others 2015) in the Middle East (WHO 2014b) has provided a regional overview as well as between-country comparison of policy and program initiatives, which can help guide decision making and selection of areas for investment.

Examples of country action are useful for sharing lessons of what did and did not work. Recent work assessing programs in Brazil, Canada, Colombia, and Finland provides an interesting contrast. Both Brazil and Colombia developed their national programs from a base of well-evaluated city-scale programs, while Canada implemented a sustained national mass media campaign (ParticipACTION) over decades to promote the benefits of physical activity and establish strong and enduring awareness in the community (Pratt, Perez, and others 2015). Finland benefited from the strong cultural value placed on physical activity combined with a steady flow of supportive programs, local government grants, and other initiatives coordinated by a national steering committee. Both Canada and Finland had good preexisting infrastructure, public open spaces, and 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 obtain 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 percent and 6 percent of national health care costs are attributable to physical inactivity. Good evidence suggests that effective interventions can increase population-level physical activity by encouraging activity in 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 yet socially or culturally viewed as desirable. Although there is a strong global policy framework 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. 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 changes to the physical environment to support active lifestyles. Site-specific interventions can improve schools, worksites, and even primary health care settings to provide significant benefits.

National strategies to promote physical activity should include policies and programs across multiple settings, and these approaches need to be adapted to the country context and culture. Strong political leadership is needed to raise the priority given to physical activity as part of the NCD-prevention agenda, and cross-sector engagement using participatory approaches and community engagement is critical to success.

ANNEXES

The annexes to this chapter are as follows. They are available at http://www.dcp-3.org/CVRD.

- Annex 5A. Summary of Results on Direct Costs of Inactivity from 18 Studies between 1980–2014
- Annex 5B. Tabulation of the Population Strategies and Interventions to Increase Physical Activity Levels at Multiple Levels of Interventions
- Annex 5C. New Zealand's Green Prescription (GRx)

NOTES

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World Bank Income Classifications as of July 2014 are as follows, based on estimates of gross national income (GNI) per capita for 2013:

- Low-income countries (LICs) = US$1,045 or less
- Middle-income countries (MICs) are subdivided:
  (a) lower-middle-income = US$1,046 to US$4,125
  (b) upper-middle-income (UMICs) = US$4,126 to US$12,745
- High-income countries (HICs) = US$12,746 or more.

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