Hallal, P. C., Andersen, L. B., Bull, F., Guthold, R., Haskell, W., Ekelund, U. (2012). Global physical activity levels: surveillance progress, pitfalls, and prospects. *The Lancet, 380,* 247-257.

Physical activity levels of the world's population

Surveillance progress, gaps and prospects

Pedro C Hallal, Lars Bo Andersen, Fiona C Bull, Regina Guthold, William Haskell, Ulf Ekelund, for the Lancet Physical Activity Series Working Group*

* Members listed at the end of the paper

Universidade Federal de Pelotas, Brazil (Dr. Pedro C. Hallal), **Department of Exercise Epidemiology, Center for Research in Childhood Health, University of Southern Denmark, Denmark** (Dr. Lars Bo Andersen), **School of Population Health, The University of Western Australia, Perth, Australia** (Prof. Fiona Bull), **Department of Chronic Diseases and Health Promotion, World Health Organization, Switzerland** (Dr. Regina Guthold), **Stanford Prevention Research Center, Stanford University School of Medicine, Unites States of America** (Prof. William Haskell), **Medical Research Council Epidemiology Unit, Cambridge, United Kingdom and Department of Sport Medicine, Norwegian School of Sport Sciences, Oslo, Norway** (Dr. Ulf Ekelund and Dr. Lars Bo Andersen)

Correspondence to: Pedro C Hallal, Marechal Deodoro 1160 – 96020-220 - Pelotas, RS, Brazil – Phone (fax): +55 53 3284-1300 - Email: prchallal@gmail.com

Text: 4,663 words; Summary: 141 words; References: 148; Figures: 6; Tables: 1; Web Appendix: 1; Web Table: 1; Web Figure: 1; Panels: 2

SUMMARY

To help policy makers implement effective non-communicable disease prevention programs, data on physical activity prevalence and trends are essential. We describe physical activity levels worldwide using adult data from 122 countries and adolescent data from 105 countries. The prevalence of physical inactivity in adults was 31.1% (95%CI being calculated), ranging from 17% (95%CI being calculated) in South-East Asia to approximately 43% in the Americas and the Eastern Mediterranean region. Inactivity increased with age and was higher in women and in wealthier countries. The proportion of 13-15 year-olds performing fewer than 60 minutes/day of moderate-to-vigorous intensity physical activity was 80.3% (95%CI 80.1; 80.5); boys were more active than girls. Continued improvement in monitoring population levels of physical activity can help guide the development of policies and programs to increase physical activity and reduce the burden of non-communicable diseases in the 21st century.

Key messages

- Surveillance of physical activity levels of adult and adolescent populations has progressed substantially in the last decade. Available data collected using standardised self-report instruments now provide estimates of physical activity for 122 countries, or two thirds of the 194 World Health Organization Member States; these data should be used to inform policy and practice worldwide.
- Available data show that globally one third of adults and four out of five adolescents do not reach public health guidelines on recommended levels of physical activity.
- Notable disparities exist in the prevalence of physical inactivity; in most countries inactivity is higher in females compared with males and older adults are less active than younger adults. These consistent patterns should be used to help policy makers implement effective non-communicable disease prevention and treatment programs.
- Trend data from high-income countries suggest that occupational physical activity is declining and there has been an increase in leisure-time physical activity among adults. There are insufficient data from low- and middle-income countries to explore patterns of activity over time and domain.
- Gaps in surveillance of physical activity remain. No data are available from about 1/3 of the world's countries, mostly low- and middle-income nations in Africa and Central Asia. Data on trends in physical activity are scarce.
- The World Health Organization's STEPwise approach to risk factor surveillance provides a good framework and practical set of tools for initiating physical activity surveillance in low- and middle-income countries in particular.
- Advances in new technologies and measurement methods, especially accelerometry, show promise for future surveillance of physical activity. These devices have potential widespread practical application if equipment costs continue to decline and sufficient efforts are directed towards increasing technical skills and workforce capacity in low- and middle-income countries.

PHYSICAL ACTIVITY IN A CHANGING WORLD

Starting with the industrial revolution, the development of new technologies has enabled humans to reduce the amount of physical labour needed to accomplish numerous tasks throughout their daily lives. As the availability of new technologic devices has continued to increase, the impact on physical labour and consequences on human energy expenditure has expanded to more aspects of the lives of more and more people. The impact of some of these technologies on reducing physical activity is very obvious (e.g., steam, gas and electric engine; trains automobiles, trucks) while others are more subtle and complex (e.g., televisions, computers, electronic entertainment, the internet, and wireless communication devices).

The use of many of these technologies has been driven by the goal of achieving greater individual worker productivity and to reduce physical hardships and disabilities caused by jobs requiring continuous heavy labour. However, the human body has evolved over the millennia in such a manner that most of its systems (e.g., skeletal, muscle, metabolic, cardiovascular) do not develop and function in an optimal manner unless activated by frequent physical activity.[1] While this technology revolution has been of great benefit to many populations throughout the world, it has come at a major cost in terms of the contribution of physical inactivity to the worldwide epidemic of non-communicable diseases (NCDs).[2] In 2009 physical inactivity was identified as the fourth leading risk factor of NCDs and accounted for over 3 million preventable deaths.[3]

Comparing patterns of participation in physical activity between countries and across world regions was an unachievable goal until a decade ago,[4] largely due to the absence of standardised instruments suitable for international use. Both barriers reflected a collective 'blind spot', because the evidence on the health benefits of physical activity had grown stronger[5] thus underpinning the importance of collecting surveillance data to guide national action.[6] In the absence of a suitable instrument, earlier efforts to characterise patterns of physical activity frequently applied measures of occupational classification or estimations of leisure-time physical activity energy expenditure as the best available indicators. This was the case in early ground breaking epidemiological studies conducted by Morris et al.[7 8] and later in the Harvard Alumni studies conducted by Paffenbarger and colleagues, respectively.[9] It was only during the late 1990's that an international group of academics developed a standardised instrument for assessing physical activity worldwide, and proceeded to test its validity and reliability in 12 countries.[10] The development of the International Physical Activity Questionnaire (IPAQ) and later similar work leading to the development of the Global Physical Activity Questionnaire (GPAQ) provided the much needed measurement instruments to support national monitoring and the inclusion of physical inactivity in risk factor surveillance systems.[11] As a result, comparable data collected through IPAQ and GPAQ in about two thirds of the countries globally now provide for the first time the opportunity for a comparative assessment of global patterns of physical activity.

The aim of this first article of the Lancet Physical Activity Series is thus to present a picture of physical activity levels of the world's population, showing the differences in participation between regions and populations as well as patterns in different types of physical activity, namely walking and vigorous-intensity activity. Due to the particular

and highly relevant synergies between health, physical activity and the environment, we also describe patterns of 'active transportation', which combines walking and cycling. We also highlight the gaps that remain in physical activity surveillance, in particular the lack of trend data in the majority of countries and the absence of data in many low- and middle-income countries. Because new technology may offer greater scope for surveillance in the future, we provide a snapshot of data collected through motion sensors in adults and young people. We also present data on the emerging science of sedentary behaviours, overview what is known about trends in physical activity and highlight the importance of using surveillance data to drive national and global action.

HOW (IN)ACTIVE IS THE WORLD'S POPULATION?

Self-reported physical activity (adults)

We obtained comparable estimates on physical inactivity for adult populations from 122 countries using the World Health Organization (WHO) Global Health Observatory Data Repository.[12] The combined population of these 122 countries represents 88.9% of the world's total population. For the present analysis, physical inactivity was defined as not meeting any of the following criteria: a) 30 minutes of moderate-intensity physical activity on at least 5 days each week, b) 20 minutes of vigorous-intensity physical activity on at least 3 days each week, or (c) an equivalent combination achieving 600 metabolic equivalent (MET)-min per week.[13-15] One MET is defined as the energy spent when sitting quietly. This resting metabolic rate was multiplied by 4 for moderate-intensity activity, and by 8 for vigorous-intensity activity. [13-15] Inclusion criteria for country data to be considered for the comparable estimates required, amongst others,

assessment of physical activity on all-domains (i.e. leisure-time, occupation, transportation and housework). Further details about the methods used to analyse these data are presented in Web Appendix 1.

The overall prevalence of physical inactivity worldwide for adults was 31.1% (95%CI being calculated). This global prevalence represents the weighted average of the prevalence in the 122 countries studied, taking into account the population of each country. There were wide variations in the prevalence of inactivity across WHO regions: Africa (27.5%; 95%CI being calculated), Americas (43.3%; 95%CI being calculated), Eastern Mediterranean (43.2%; 95%CI being calculated), Europe (34.8%; 95%CI being calculated), South-East Asia (17.0%; 95%CI being calculated) and Western Pacific (33.7%; 95%CI being calculated) (Figure 1). Globally, women were more inactive (33.9%) than men (27.9%). Web Table 1 displays individual country results; there were wide differences across countries, for example the prevalence of inactivity for both sexes combined ranged from 4.7% (95%CI 4.3; 5.1) in Bangladesh to 71.9% (95%CI 31.0; 87.2%) in Malta.

In Figure 2 we show that inactivity increases with age in all WHO regions, a pattern known to have a strong biological basis.[16] In spite of the linear association being observed in all regions, heterogeneity was marked. For example, older adults (60+ years) from South-East Asia were much more active than older adults from all other regions, and actually more active than young adults (15-29 years) from the Americas, the Eastern Mediterranean, European and Western Pacific regions.

Figure 3 presents physical inactivity by World Bank income classification. The prevalence of physical inactivity was higher in wealthier countries. For years, surveys focusing solely on leisure-time physical activity suggested that within countries, physical inactivity was more frequent among the poor as compared to those of higher socioeconomic status.[17 18] It was only in the last decade, when standardised instruments focused on total physical activity (i.e. leisure-time, occupational, housework and transport-related activity) that a different social patterning of inactivity became apparent.[4 19] Whether or not this pattern will persist in the future is unknown, but evidence from a study in Brazil suggests that while the prevalence of physical inactivity increased sharply among the poor in a five-year period, no significant differences were observed among the better-off. [20] The hypothesis that the social patterning of physical inactivity might be shifting is reinforced by declining occupational physical activity levels (more frequent among the poor) and increases in leisure-time physical activity (more frequent among the rich) reported in a systematic review.[21]

Walking is a common, accessible, inexpensive form of physical activity and has been shown to be an important component of total physical activity among adult populations.[22] Walking is an aerobic activity requiring use of large skeletal muscles that confers the multifarious benefits of physical activity for health with minimal adverse effects.[23] Interventions aimed at increasing population levels of walking exist and have proven its efficacy.[24] We estimated the proportion of adults reporting walking for at least 10 consecutive minutes on five or more days per week. Overall, global prevalence was 64.1% (95%CI being calculated), but interestingly, the variation across WHO regions was modest: Africa (57.0%; 95%CI being calculated), Americas (65.6%; 95%CI being calculated), Eastern Mediterranean (66.9%; 95%CI being calculated),

Europe (66.8%; 95%CI being calculated), South-East Asia (67.2%; 95%CI being calculated) and Western Pacific (65.0%; 95%CI being calculated). Moreover there was almost no difference in patterns of walking between men and women and across age groups (Figure 4). This is in part explained by the measurement of all types of walking, namely recreation, transport and occupational walking.

Participation in vigorous-intensity physical activity is another key indicator of physical activity levels. There are well-established health benefits from undertaking activity at vigorous-intensity[5] and this was recognised in the recent WHO Global Physical Activity Recommendations.[14] Moreover, there is evidence that vigorous compared with moderate intensity activity has higher reliability and validity in standardised self-report instruments.[10] We therefore estimated the proportion of adults reporting three or more days per week, of vigorous-intensity physical activity. The overall prevalence was 31.4% (95%CI being calculated), and marked differences across regions were detected: Africa (38.0%; 95%CI being calculated), Americas (24.6%; 95%CI being calculated), Eastern Mediterranean (43.2%; 95%CI being calculated), Europe (25.4%; 95%CI being calculated), South-East Asia (43.2%; 95%CI being calculated), Western Pacific (35.3%; 95%CI being calculated). Within each age category, men were more likely to participate in vigorous-intensity physical activity than women. Also, both in men and women, vigorous-intensity physical activity participation decreased with age (Figure 4).

Self-reported physical activity (adolescents)

There are substantial short- and long-term health benefits from regular physical activity for young people.[25] However, measurement of physical activity in children is

complex.[26] Although some countries have established monitoring of activity in specific age groups, rarely does this extend to include repeated measures over time. Globally, most progress has focussed on the adolescent population. To date, the two most comprehensive sources of data on adolescent physical activity levels are the Global School-Based Student Health Survey (GSHS)[27] and the Health Behaviour in School-Aged Children (HBSC) survey.[28]

Using the GSHS publically available data (http://www.who.int/chp/gshs/en/), we estimated the proportion of 13-15 year-old adolescents reaching the public health goal of ≥ 60 min/day of moderate-to-vigorous physical activity (MVPA) practice for 66 mostly low- and middle-income countries. From the HBSC published articles, reports and access to available raw data, [29 30] we assessed the proportion of 13-15 year-old adolescents achieving 60 MVPA-minutes per day for 38 European countries, the United States and Canada. Combining data from the two surveys, provided estimates for 105 countries (data from Macedonia were available in both data sources, therefore we averaged the two values).

Figure 5 shows the proportion of boys and girls aged 13-15 who do not reach 60 minutes per day of MVPA. The global prevalence estimate was 80.3% (95%CI 80.1; 80.5). Girls were less active than boys. Prevalence estimates were much higher than those observed among adults. The proportion of adolescents not achieving the 60 minutes per day threshold was equal to or greater than 80% in 56 (53%) out of 105 countries among boys, and 100 (95%) out of 105 countries among girls. It should be stressed that the instruments employed in these adolescent studies focus on leisure-time

activities, whereas among adults, IPAQ and GPAQ assess four domains of physical activity.

Active transportation

Active transportation, namely walking and cycling to get to and from places can provide health benefits [31 32] and may offer a potential opportunity to increase physical activity levels of whole populations.[24 33-35] Many studies have shown beneficial effects of commuter walking and cycling for all-cause mortality[32 36] and several diseases.[36-42] In children, associations have been found between active commuting to school and lower body mass index[43] and better cardiovascular risk factor profile. [44-47]

Data on active transportation are derived from different sources (e.g. population studies, transport research). Comparing data from different countries is particularly difficult due to lack of standardisation in instruments and use of different indicators (e.g. prevalence of people walking or cycling to work, percentage of trips using different transport modes). Moreover, some studies combine walking and cycling whereas others analyse the two modalities separately.

We searched the literature for recent systematic reviews [34 39 48 49] and original articles published from 2010 onwards, and internet for national statistics mainly from Transport Ministries to identify prevalence of active transportation. We found prevalence statistics of proportion of people walking to work for 14 countries (Table 1).[50-66] Walking to work was less frequent (<4%) in Switzerland, the United States and Australia and more frequent (>20%) in China, Germany and Sweden. We found data on the prevalence of

adults cycling to work for 13 countries.[32 39 51 53-55 57 58 61 63 65-72] The prevalence was low (<2%) in Australia, Canada, Ireland, Switzerland, the United Kingdom and the United States, and high (>20%) in China, Denmark and The Netherlands. Finally, we located data on active transportation to work (walking plus cycling) for 15 countries.[50 54 57 58 60 62 63 65 66 68 73-78] Prevalence of lower than 5% in Australia, Switzerland and The United States and higher than 20% in China, France, Germany, Sweden and The Netherlands. Data from low-income countries are lacking.

Most walking commuters have less than 1 km to work, or combine walking with public transport. Cyclists cover longer distances, but are limited by unsafe environments and lack of bike lanes. However, major differences exist even between countries with similar geography, population density and climate (e.g. cycling to work was 2% in the United Kingdom and over 25% in Denmark and Holland), suggesting that other factors also contribute. For example in Denmark, building infrastructure to promote cycling resulted in a 50% increase in cycling over the last two decades.[79]

Although active transportation is beneficial for health and for the environment, its promotion should also take into account unintended consequences. In several parts of the world, pedestrian and cyclist safety are serious concerns, although the benefits from cycling far outnumber risks. For example, if all non-cyclists in Denmark would become cyclists, around 12,000 deaths would be saved each year as a result of cycling activity, while only 30 cyclists are killed in traffic accidents annually[32]. However, the picture is likely different in many mega cities from both high-income and low- and middle-income countries. Our global challenge is to help improve pedestrian and cyclist safety

and city environments so that active transportation becomes not only a healthy alternative, but also a safe one.

Objectively measured physical activity

New technologies applied to the measurement of body movement have emerged as an alternative method to measure physical activity. Instruments such as accelerometers provide new ways to estimate the frequency, duration and intensity of physical activity in free-living individuals. [80] Importantly, these methods avoid some of the inherent limitations of self-report instruments, namely recall bias. To date, accelerometry has been widely implemented in small scale research surveys, but more recently their application has been tested within population based surveillance systems in a number of developed countries (see Panel 1).

Here, we present a summary of available data on the amount of time spent in MVPA using accelerometry. For adults, we performed a systematic literature search for articles in which physical activity was measured by the Actigraph accelerometer. Inclusion criteria were: healthy adults > 18 years, MVPA measured for at least four days; physical activity measured for at least 600 minutes per day; MVPA defined as either ≥ 1952 or ≥ 2020 counts per minute. If the same study was included in multiple reports only results from one of these were extracted and included. In total, data from 35 reports, comprising 13 countries and >19,000 individuals were extracted.[81-114] Data on time in MVPA from individual studies were combined using random effect meta-analysis by geographical region - North America (N=6,808), Europe (N=9,638), Western Pacific (N=725) and others (N=1990) (Ulf Ekelund and Hao Guo, personal communication).

For youth, we used data from the International Children's Accelerometer Database (ICAD),[115] comprising >30,000 individuals aged 4-18 years from 21 studies in 10 countries. In youth, all raw accelerometer data files were reanalysed using the same data cleaning and data reduction criteria. For comparability with data presented in adults, MVPA was defined as all minutes in a day ≥ 2000 counts/minute, adjusted for sex and age.

For adults, the mean accumulated minutes of MVPA was about 37.5 minutes per day (Web Figure 1). Mean MVPA was significantly higher in adults from the Western Pacific (Australia and New Zealand) region as compared with those from North America and Europe ($P<0.01$), but there were no differences between North American and European adults. Among youth, the highest values were observed for Norway, Switzerland, Estonia and Australia, whereas data from Belgium, Brazil and the United States were remarkably lower than the pooled adjusted mean of approximately 65 minutes of MVPA per day. Highly significant heterogeneity between countries was observed.

Caution is warranted when comparing accelerometry data with self-report. The majority of time in MVPA from accelerometry is accumulated in bouts shorter than 10 minutes.[116], whereas self-report instruments usually prompt the respondent to report activities in bouts lasting at least 10 minutes.[10] In addition, most accelerometer data presented here are derived from high-income countries, which were shown to be less active than low and middle-income ones (see Figure 3).

Sedentary behaviour

In addition to physical activity, another aspect of the human movement spectrum that has received recent attention is sedentary behaviour, usually defined as time spent sitting. Similarly to physical activity practice, sedentary behaviours take place in different domains (i.e. at work, for leisure and entertainment - e.g. watching TV - and whilst commuting).[117] So far, little is known about the patterns of sedentary behaviour in different countries,[118] mainly because it has only relatively recently been recognised as a public health issue and therefore there is a lack of standardised instruments for assessing this behaviour.[119] However, using available data from the STEPS surveys, the Eurobarometer, and the International Prevalence Study, we were able to assess and compare time spent sitting for 66 countries.

Overall, the proportion of adults spending four or more hours per day sitting was 41.5% (95%CI being calculated), with a wide variation across WHO regions: Africa (37.8%; 95%CI being calculated), Americas (55.2%; 95%CI being calculated), Eastern Mediterranean (41.4%; 95%CI being calculated), Europe (64.1%; 95%CI being calculated), South-East Asia (23.8%; 95%CI being calculated) and Western Pacific (39.8%; 95%CI being calculated). For men and women, and for adults 15-59 years of age, the prevalence of persons spending ≥4 hours/day sitting was similar; for individuals aged ≥60 years the prevalence was higher (Figure 6).

Other recent work by Bauman and colleagues presented sitting time for a set of 20 countries.[118] They reported a median of 300 minutes/day, wide variability across countries, and higher sitting times among middle-aged adults compared with young adults,[84] a finding that was not replicated in our analyses including 66 countries.

Among adolescents, using HBSC data from 40 countries, it was estimated that 66% of the boys and 68% of the girls aged 13-15 years spend two or more hours per day watching television. In every country studied, with the exception of Switzerland, over half of the boys and girls spent two or more hours per day watching television. Using data from GSHS in 34 countries, Guthold and colleagues found that in more than half of the countries, more than 1/3 of the students spent three or more hours per day on sedentary activities.[120]

TIME TRENDS IN PHYSICAL ACTIVITY PRACTICE

A number of behavioural and environmental factors, as well as mega-trends influence population levels of physical activity.[121] Rapid urbanisation, mechanisation and increased use of motorised transport may have generated changes in physical activity globally. [122 123] Examples of national surveillance systems aimed to assess secular changes in physical activity are scarce, most are relatively recent, and the majority of data are from high-income countries.

A recent systematic review found an increase in adults' leisure time physical activity, including sports participation, in recent years.[21] The evidence for a slight increase in leisure time physical activity appeared consistent and was supported by more recent studies from Canada,[124] Spain,[125] Sweden,[126] and England.[127] Authors also reported a simultaneous decline in occupational physical activity.[21 125 127] A comprehensive analysis of United States data showed that daily energy expenditure in work-related physical activity has declined by more than 100 calories per day during the last 50

years.[128] Data on time trends in physical activity from low and middle income countries are extremely sparse and when available, contradictory.[20 129 130]

The magnitude and direction of changes in physical activity over time in young people are less clear cut. A recent systematic review including studies from five high-income countries concluded that physical activity during physical education classes have declined.[21] Also, there is evidence of a decline in active transportation in the United States,[131] Switzerland,[132] and Canada.[133] A review focusing on different domains of activity concluded that the available evidence does not support the notion that overall physical activity levels and sport participation have declined recently in youth.[134] Similar to adults, the paucity of data on secular changes in physical activity from low- and middle-income countries is concerning.

Very few studies from a limited number of high income countries have examined time trends in physical activity by objective methods. In Japan, the proportion of adults achieving 10,000 steps per day declined by 5% from 2000 to 2007.[135] In youth populations, declines in physical activity were observed among Czech boys between 1998-2000 and 2008-2010,[136] and among Canadian boys and girls from 2001 to 2006.[137] Contrary to these findings, a study in Sweden reported increases in accumulated steps per day between 2000 and 2006 among boys and girls aged 7-9 years.[138]

In summary, it seems that among adults leisure-time physical activity is increasing, whereas occupational and transport-related activity levels are declining. Data on time trends of physical activity among adolescents are inconsistent.

DATA AVAILABILITY: SURVEILLANCE PROGRESS, GAPS AND PERSISTENT PROBLEMS

Much progress has been made in the availability of national population level data on physical activity particularly among adults, in the last decade. It is notable that in 2002, national data on physical activity were identified for only 43 countries, but comparability was limited due to the use of many different measurement instruments.[4] Following the development of IPAQ and GPAQ comparable data are now available for from 122 countries for adult populations. For adolescent populations, global school based surveillance systems have been developed and there are data available for 105 countries. Collectively, these data provide a global picture of the pattern of participation and exposure to the risk of inactivity, and provide the basis for national policy development as called for by the Global Strategy for Diet, Physical Activity and Health[139] and to guide practice at the national and local community levels.

Although considerable progress has been made in physical activity surveillance, there are also notable gaps. One is the lack of continuous surveillance systems implemented at the national level, impeding most countries to analyse trends data. Actually, well-established surveillance systems on physical activity are a luxury available only in a very limited number of countries, most of which are highly developed. In Panel 1, we highlight the United States case study. Another limitation is that the distribution of countries with no data is not random. Data gaps are concentrated in Africa, the poorest parts of Latin America and Central Asia. A good example on how physical activity surveillance can be initiated and sustained in low- and middle-income countries is the World Health Organization STEPwise approach, highlighted in Panel 2.

Case Study 1: Physical activity surveillance in the United States

Physical activity surveillance in the United States has included national and state-based surveys. The National Health and Nutrition Examination Survey (NHANES) is a population-based survey collecting information on the health and nutrition of the United States population (www.cdc.gov/nchs/nhanes.htm). Health examination surveys were conducted through the 1960's and followed by the NHANES from 1971 onwards. There are two parts to this survey: the home interview and the health examination. Physical activity questions were introduced in 1999, allowing analyses of secular trends in the proportion of physical inactivity and its correlates. NHANES provides data for adults (leisure-time, transportation and household activities) and children (leisure-time activities). In 2003, accelerometry data were collected in addition to self-report.

In addition to NHANES, surveys started to be conducted in the 80's to monitor the prevalence of the major behavioural risks associated with premature morbidity and mortality. Data collection was systematized as the Behavioral Risk Factor Surveillance System (BRFSS) in 1984. Currently, data are collected monthly in all 50 states, the District of Columbia, Puerto Rico, the United States Virgin Islands, and Guam. More than 350,000 people are interviewed each year, making the BRFSS the largest telephone health survey in the world. Data from BRFSS have intensively been used for research. Physical activity questions asked between 1984 and 2000 focused only on leisure-time activities. However, beginning in 2001, other domains of physical activity were added to the survey to include domestic or household activities, transport-related and leisure-time physical activity. While occupational activities are also included in the questionnaire, these types of activities are not included in the total physical activity score. In the 2011 version of the BRFSS, eight core physical activity questions were incorporated. The surveillance system also includes youth (YRBS). This system surveys adolescents in grades 9-12 and includes over 15,000 participants per year. Leisure-time, transport-related, and domestic domains of physical activity are assessed, as well as participation in Physical Education.

Case study 2: The WHO STEPwise approach to chronic disease risk factor surveillance (STEPS)

This approach was initiated in 2000 to assist low- and middle-income countries in collecting data on risk factors for major non-communicable diseases (NCDs). The overall goal is to build and strengthen country capacity to conduct risk factor surveillance within the framework of an integrated, systematic approach aimed at sustainable collection of data.[140] By using the same standardised questions and protocols, all countries can use STEPS information not only for monitoring within-country trends, but also for making comparisons across countries. The Global Physical Activity Questionnaire (GPAQ) was developed for physical activity data collection in STEPS. This instrument captures physical activity at work/in the household, for transport, and for leisure time separately. [11] The use of show cards and culturally specific examples for each activity type covered in the questionnaire ensures proper understanding of the questions on the one hand, and cultural adaptation on the other hand.

In 2000, physical activity data were only available for two countries of the WHO African Region.[4] Two years later, ten of the 46 African countries had been trained on how to implement the STEPS approach, while this number had increased to 35 by early 2006. By then, 11 countries had already successfully conducted a STEPS survey. In the meantime, all African countries have received STEPS training, and physical activity data are now available for the 35 countries that have completed a survey, including 5 countries that have completed two surveys. 26 countries have published the results of their surveys in country reports and/or journal articles.[141] In 10 of the African countries that have completed a STEPS survey, eSTEPS has been implemented, that is, data collection with hand-held computers that was introduced in 2009.

TRANSLATING KNOWLEDGE INTO ACTION

Approximately two thirds of all WHO Member States have at least some data on population levels of physical activity, which is a great surveillance achievement. However, there is still room for improvements, including data collection in the countries with no data, as well as establishing routine surveillance systems widely. Data are more frequently available on adult populations compared with adolescents, and for all age groups, lack of data is more frequent in low- and middle-income countries. Action is needed to increase the extent and frequency of national level data collection on a global scale, but this is just the first step as it is well established that data availability does not necessarily translate into action.

Our findings in terms of physical activity levels and trends of the world population are extremely concerning. Around 3 out of every 10 individuals aged 15 years or more in the world do not reach current physical activity recommendations[5 14], which represents approximately 1.5 billion people. The situation among adolescents is even more concerning, with a worldwide estimate that 4 out of every 5 adolescents aged 13-15 years do not reach current physical activity recommendations. As summarized in the paper by Lee and colleagues,[142] these individuals are at higher risk of developing coronary heart disease, diabetes, some types of cancer and several other diseases, as well as of dying prematurely.

Some methodological issues about available surveillance data should be raised. The estimates presented here were corrected for the well-known over-reporting of physical activity when using the IPAQ (see Web Appendix 1),[143-146] and adjusted our values for

age and region (urban vs. rural), two factors known to influence physical activity behaviours. By using these strategies, the well-known limitations of self-report in adult populations were minimised. In spite of these procedures, there is evidence that especially in terms of housework and occupational physical activity, self-reports are extremely difficult, particularly in low- and middle-income countries,[147] where transport, occupational and housework activities are often mixed in daily life. An additional concern is that perceptions about the meaning of 'physical activity' may vary across countries, sexes and age groups, particularly due to the fact that people tend to compare themselves to their peers when replying to physical activity questions.[126] Fortunately, alternatives to overcome this issue have been proposed and implemented, such as the use of show-cards and culturally relevant examples (see Panel 2). Another limitation to be considered is that not all samples were representative of the whole country's population. These limitations of available self-reported data may partially explain the large differences observed in the prevalence of physical inactivity across countries. Finally, the limitations of data currently available on sedentary behaviour should be acknowledged, because surveillance information is typically restricted to single items instead of standardised and validated instruments.[148] Furthermore, available data on active transportation come from different sources and few countries.

As public health efforts to increase physical activity and decrease sedentary time proceed, it will be very important that standardised physical activity surveillance procedures are implemented more broadly and repeatedly. These measures are needed to understand which intervention strategies work for which populations as well as to identify target populations at greatest risk. Two validated questionnaires have been successfully implemented across countries and cultures, but additional development is

needed to effectively assess specific domains of physical activity, especially active transportation and sedentary behaviours. Existing surveillance systems would need to be expanded to include these specific aspects. Advances in new technologies and measurement methods, especially accelerometry, show promise for future surveillance of physical activity. These devices have potential widespread practical application if equipment costs continue to decline and sufficient efforts are directed towards increasing technical skills and workforce capacity in low- and middle-income countries.

Shifting population levels of physical activity through better use of existing surveillance data is a major challenge for the 21st Century as societal trends are leading to less not more activity. Our traditional public health approach based on evidence and exhortation has to some extent failed so far. With very few exceptions, we have been unable to mobilise governments and populations to take physical inactivity sufficiently seriously as a public health issue. The results presented here show clear progresses in physical activity surveillance, in part because the growing burden of NCDs prompted governments and international agencies to monitor this behaviour worldwide. One should keep in mind that these achievements were only made possible because thousands of individuals from various parts of the world kindly provided us with information on their behaviours related to physical activity. In return, governments, policy makers and the research community need to help build societies in which the choice of being physically active is not only healthy, but also convenient, enjoyable, safe, affordable and valued.

REFERENCES

1. Booth FW, Laye MJ, Lees SJ, Rector RS, Thyfault JP. Reduced physical activity and risk of chronic disease: the biology behind the consequences. *Eur J Appl Physiol* 2008;102(4):381-90.
2. World Health Organization. Global Status Report on NCDs 2010. In: Organization WH, editor. Geneva: World Health Organization, 2011.
3. Organization WH. Global Health Risks. Mortality and burden of disease attributable to selected major risks. In: Organization WH, editor. Geneva: World Health Organization, 2009.
4. Bull FC, Armstrong TP, Dixon T, et al. Physical inactivity. In: Ezzati M LA, Rodgers A, et al, editor. *Comparative quantification of health risks. Global and regional burden of disease attributable to selected major risk factors*. Geneva: World Health Organization, 2004:729-881.
5. Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation* 2007;116(9):1081-93.
6. Bull FC, Bauman AE. Physical inactivity: the "Cinderella" risk factor for noncommunicable disease prevention. *J Health Commun* 2011;16 Suppl 2:13-26.
7. Morris JN, Heady JA, Raffle PA, Roberts CG, Parks JW. Coronary heart-disease and physical activity of work. *Lancet* 1953;265(6796):1111-20; concl.
8. Morris JN, Heady JA, Raffle PA, Roberts CG, Parks JW. Coronary heart-disease and physical activity of work. *Lancet* 1953;265(6795):1053-7; contd.
9. Paffenbarger RS, Jr., Hyde RT, Wing AL, Hsieh CC. Physical activity, all-cause mortality, and longevity of college alumni. *N Engl J Med* 1986;314(10):605-13.
10. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc* 2003;35(8):1381-95.
11. Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. *J Phys Act Health* 2009;6(6):790-804.
12. World Health Organization. Global Health Observatory Data Repository, 2011.
13. Karolinska Institute. IPAQ home page, 2011 (www.ipaq.ki.se; Accessed Jun 23rd, 2011).
14. World Health Organization. Global recommendations on physical activity for health. Geneva, 2010.
15. World Health Organization. GPAQ home page, 2011.
16. Ingram DK. Age-related decline in physical activity: generalization to nonhumans. *Med Sci Sports Exerc* 2000;32(9):1623-9.
17. Trost SG, Owen N, Bauman AE, Sallis JF, Brown W. Correlates of adults' participation in physical activity: review and update. *Med Sci Sports Exerc* 2002;34(12):1996-2001.
18. Hallal PC, Matsudo SM, Matsudo VK, Araujo TL, Andrade DR, Bertoldi AD. Physical activity in adults from two Brazilian areas: similarities and differences. *Cad Saude Publica* 2005;21(2):573-80.
19. Dumith SC, Hallal PC, Reis RS, Kohl HW, 3rd. Worldwide prevalence of physical inactivity and its association with human development index in 76 countries. *Prev Med* 2011;53(1-2):24-8.

20. Knuth AG, Bacchieri G, Victora CG, Hallal PC. Changes in physical activity among Brazilian adults over a 5-year period. *J Epidemiol Community Health* 2010;64(7):591-5.
21. Knuth AG, Hallal PC. Temporal trends in physical activity: a systematic review. *J Phys Act Health* 2009;6(5):548-59.
22. Monteiro CA, Conde WL, Matsudo SM, Matsudo VR, Bonsenor IM, Lotufo PA. A descriptive epidemiology of leisure-time physical activity in Brazil, 1996-1997. *Rev Panam Salud Publica* 2003;14(4):246-54.
23. Morris JN, Hardman AE. Walking to health. *Sports Med* 1997;23(5):306-32.
24. Ogilvie D, Foster CE, Rothnie H, Cavill N, Hamilton V, Fitzsimons CF, et al. Interventions to promote walking: systematic review. *BMJ* 2007;334(7605):1204.
25. Hallal PC, Victora CG, Azevedo MR, Wells JC. Adolescent physical activity and health: a systematic review. *Sports Med* 2006;36(12):1019-30.
26. Riddoch CJ, Bo Andersen L, Wedderkopp N, Harro M, Klasson-Heggebo L, Sardinha LB, et al. Physical activity levels and patterns of 9- and 15-yr-old European children. *Med Sci Sports Exerc* 2004;36(1):86-92.
27. World Health Organization. Global School-Based Student Health Survey. Geneva: World Health Organization, 2011.
28. WHO Collaborative Cross-National Study (HBSC) International Coordinating Centre. Health Behaviour in School-Aged Children: A World Health Organization Collaborative Cross-national Study, 2011.
29. Melkevik O, Torsheim T, Iannotti RJ, Wold B. Is spending time in screen-based sedentary behaviors associated with less physical activity: a cross national investigation. *Int J Behav Nutr Phys Act*;7:46.
30. World Health Organization Europe. Inequalities in young people's health: health behaviour in school-aged children international report from the 2005/2006 survey. Copenhagen, 2008.
31. Manson JE, Hu FB, Rich-Edwards JW, Colditz GA, Stampfer MJ, Willett WC, et al. A prospective study of walking as compared with vigorous exercise in the prevention of coronary heart disease in women. *N Engl J Med* 1999;341(9):650-8.
32. Andersen LB, Schnohr P, Schroll M, Hein HO. All-cause mortality associated with physical activity during leisure time, work, sports, and cycling to work. *Arch Intern Med* 2000;160(11):1621-8.
33. de Nazelle A, Nieuwenhuijsen MJ, Anto JM, Brauer M, Briggs D, Braun-Fahrlander C, et al. Improving health through policies that promote active travel: a review of evidence to support integrated health impact assessment. *Environ Int* 2011;37(4):766-77.
34. Yang L, Sahlqvist S, McMinn A, Griffin SJ, Ogilvie D. Interventions to promote cycling: systematic review. *BMJ* 2010;341:c5293.
35. Pucher J, Dill J, Handy S. Infrastructure, programs, and policies to increase bicycling: an international review. *Prev Med*;50 Suppl 1:S106-25.
36. Matthews CE, Jurj AL, Shu XO, Li HL, Yang G, Li Q, et al. Influence of exercise, walking, cycling, and overall nonexercise physical activity on mortality in Chinese women. *Am J Epidemiol* 2007;165(12):1343-50.
37. Hu FB, Sigal RJ, Rich-Edwards JW, Colditz GA, Solomon CG, Willett WC, et al. Walking compared with vigorous physical activity and risk of type 2 diabetes in women: a prospective study. *JAMA* 1999;282(15):1433-9.

38. Manson JE, Nathan DM, Krolewski AS, Stampfer MJ, Willett WC, Hennekens CH. A prospective study of exercise and incidence of diabetes among US male physicians. *JAMA* 1992;268(1):63-7.
39. Pucher J, Buehler R, Bassett DR, Dannenberg AL. Walking and cycling to health: a comparative analysis of city, state, and international data. *Am J Public Health* 2010;100(10):1986-92.
40. Hamer M, Chida Y. Active commuting and cardiovascular risk: a meta-analytic review. *Prev Med* 2008;46(1):9-13.
41. Manson JE, Greenland P, LaCroix AZ, Stefanick ML, Mouton CP, Oberman A, et al. Walking compared with vigorous exercise for the prevention of cardiovascular events in women. *N Engl J Med* 2002;347(10):716-25.
42. Weuve J, Kang JH, Manson JE, Breteler MM, Ware JH, Grodstein F. Physical activity, including walking, and cognitive function in older women. *JAMA* 2004;292(12):1454-61.
43. Ostergaard L, Grontved A, Froberg K, Andersen LB. Cycling to school is associated with lower BMI and lower odds of being overweight or obese in a large population-based study of Danish adolescents. *J Phys Act Health* 2011;(in press).
44. Andersen LB, Lawlor DA, Cooper AR, Froberg K, Anderssen SA. Physical fitness in relation to transport to school in adolescents: the Danish youth and sports study. *Scand J Med Sci Sports* 2009;19(3):406-11.
45. Cooper AR, Wedderkopp N, Jago R, Kristensen PL, Moller NC, Froberg K, et al. Longitudinal associations of cycling to school with adolescent fitness. *Prev Med* 2008;47(3):324-8.
46. Cooper AR, Wedderkopp N, Wang H, Andersen LB, Froberg K, Page AS. Active travel to school and cardiovascular fitness in Danish children and adolescents. *Med Sci Sports Exerc* 2006;38(10):1724-31.
47. Andersen LB, Wedderkopp N, Kristensen PL, Moller NC, Froberg K, Cooper AR. Cycling to school and cardiovascular risk factors. A longitudinal study. *J Phys Act Health* 2011;8:1025-33.
48. Bassett DR, Jr., Pucher J, Buehler R, Thompson DL, Crouter SE. Walking, cycling, and obesity rates in Europe, North America, and Australia. *J Phys Act Health* 2008;5(6):795-814.
49. Oja P, Titze S, Bauman A, de Geus B, Krenn P, Reger-Nash B, et al. Health benefits of cycling: a systematic review. *Scand J Med Sci Sports*;21(4):496-509.
50. Bell AC, Garrard J, Swinburn BA. Active transport to work in Australia: is it all downhill from here? *Asia Pac J Public Health* 2006;18(1):62-8.
51. Central Statistics Office GoI. Travel to work, school and college, 2008.
52. Department for Transport. United Kingdom National Travel Survey, 2006.
53. Federal Ministry of Transport.Germany FSO. Travel in Germany 2002: results at a glance, 2002.
54. Federal Office for Spatial Development and Federal Statistical Office. Micro Census/ Travel Behavior 2005 [in German]. Switzerland, 2005.
55. Gordon-Larsen P, Boone-Heinonen J, Sidney S, Sternfeld B, Jacobs DR, Jr., Lewis CE. Active commuting and cardiovascular disease risk: the CARDIA study. *Arch Intern Med* 2009;169(13):1216-23.
56. Kruger J, Ham SA, Berrigan D, Ballard-Barbash R. Prevalence of transportation and leisure walking among U.S. adults. *Prev Med* 2008;47(3):329-34.

57. Lee SA, Xu WH, Zheng W, Li H, Yang G, Xiang YB, et al. Physical activity patterns and their correlates among Chinese men in Shanghai. *Med Sci Sports Exerc* 2007;39(10):1700-7.
58. Lindstrom M. Means of transportation to work and overweight and obesity: a population-based study in southern Sweden. *Prev Med* 2008;46:22-28.
59. Meschik M, Skorna A, Spinka H, Teufel DWP. Radverkehr in zahlen. Daten, fakten und stimmungen. Wien, 2010.
60. Schnohr P, Scharling H, Jensen JS. Intensity versus duration of walking, impact on mortality: the Copenhagen City Heart Study. *Eur J Cardiovasc Prev Rehabil* 2007;14:72-78.
61. Statistics Canada. Where Canadians work and how they get there, 2008.
62. Statistics Netherlands. National travel survey, 2008.
63. Tin Tin S, Woodward A, Thornley S, Ameratunga S. Cycling and walking to work in New Zealand, 1991-2006: regional and individual differences, and pointers to effective interventions. *Int J Behav Nutr Phys Act* 2009;6:64.
64. Wen LM, Rissel C. Inverse associations between cycling to work, public transport, and overweight and obesity: findings from a population based study in Australia. *Prev Med* 2008;46(1):29-32.
65. Central Statistics Office. Volume 12-Travel to work, school and college, 2006.
66. Department of Transport. Transport statistics bulletin. National travel survey: 2002. 2004. London: Stationary Office, 2004.
67. Lynam D, Nilsson G, Morsink P, Sexton B, Twisk D, Goldenbeld B. An extended study of the development of road safety in Sweden, the United Kingdom, and the Netherlands. The Netherlands: Institute for Road Safety Research, 2005.
68. Pucher J, Buehler R, Merom D, Bauman A. Walking and Cycling in the United States, 2001-2009: Evidence From the National Household Travel Surveys. *Am J Public Health* 2011;(in press).
69. Pucher J, Buehler R, Seinen M. Bicycling renaissance in North America? An update and re-appraisal of cycling trends and policies. *Transportation Research Part A* 2011;45:451-75.
70. Wen LM, Fry D, Merom D, Rissel C, Dirkis H, Balafas A. Increasing active travel to school: are we on the right track? A cluster randomised controlled trial from Sydney, Australia. *Prev Med* 2008;47(6):612-8.
71. Stigell E. Assessment of active commuting behavior - walking and bicycling in Greater Stockholm. Örebro: Örebro University., 2011:1-137.
72. Danish Ministry of Transport. Number of trips per person per day, 2008.
73. Florindo AA, Hallal PC, Moura EC, Malta DC. Practice of physical activities and associated factors in adults, Brazil, 2006. *Rev Saude Publica* 2009;43 Suppl 2:65-73.
74. Hu G, Eriksson J, Barengo NC, Lakka TA, Valle TT, Nissinen A, et al. Occupational, commuting, and leisure-time physical activity in relation to total and cardiovascular mortality among Finnish subjects with type 2 diabetes. *Circulation* 2004;110(6):666-73.
75. Schnohr P, Marott JL, Jensen JS, Jensen GB. Intensity versus duration of cycling, impact on all-cause and coronary heart disease mortality: the Copenhagen City Heart Study. *Eur J Cardiovasc Prev Rehabil* 2011;(in press).
76. Wagner A, Simon C, Ducimetiere P, Montaye M, Bongard V, Yarnell J, et al. Leisure-time physical activity and regular walking or cycling to work are

associated with adiposity and 5 y weight gain in middle-aged men: the PRIME Study. *Int J Obes Relat Metab Disord* 2001;25(7):940-8.
77. Florindo AA, Guimaraes VV, Cesar CL, Barros MB, Alves MC, Goldbaum M. Epidemiology of leisure, transportation, occupational, and household physical activity: prevalence and associated factors. *J Phys Act Health* 2009;6(5):625-32.
78. Hu G, Qiao Q, Silventoinen K, Eriksson JG, Jousilahti P, Lindstrom J, et al. Occupational, commuting, and leisure-time physical activity in relation to risk for Type 2 diabetes in middle-aged Finnish men and women. *Diabetologia* 2003;46(3):322-9.
79. Danish Ministry of Transport and Energy. More bikes on safe roads in Denmark, 2012.
80. Chen IJ, Chou CL, Yu S, Cheng SP. Health services utilization and cost utility analysis of a walking program for residential community elderly. *Nurs Econ* 2008;26(4):263-9.
81. Assah FK, Ekelund U, Brage S, et al. Predicting Physical Activity Energy Expenditure Using Accelerometry in Adults From Sub-Sahara Africa. Obesity 2009; 17: 1588-95.
82. Trinh OTH, Nguyen DN, van der Ploeg HP, et al. Test-Retest Repeatability and Relative Validity of the Global Physical Activity Questionnaire in a Developing Country Context. J Phys Act Health 2009; 6: S46-S53.
83. Macfarlane DJ, Lee CCY, Ho EYK, et al. Convergent validity of six methods to assess physical activity in daily life. J Appl Physiol 2006; 101:1328-34.
84. Lee PH, Yu YY, McDowell I, et al. Performance of the international physical activity questionnaire (short form) in subgroups of the Hong Kong chinese population. Int J Behav Nutr Phys Act 2011; 8: 81.
85. Celis-Morales CA, Perez-Bravo F, Ibanes L, et al. Insulin Resistance in Chileans of European and Indigenous Descent: Evidence for an Ethnicity x Environment Interaction. PLoS One 2011; 6: 9.
86. Tudor-Locke C, Ainsworth BE, Thompson RW, et al. Comparison of pedometer and accelerometer measures of free-living physical activity. Med Sci Sports Exerc 2002; 34: 2045-51.
87. Matthews CE, Ainsworth BE, Thompson RW, et al. Sources of variance in daily physical activity levels as measured by an accelerometer. Med Sci Sports Exerc 2002; 34: 1376-81.
88. Whitt M, Kumanyika S, Bellamy S. Amount and bouts of physical activity in a sample of African-American women. Med Sci Sports Exerc 2003; 35: 1887-93.
89. Schmidt MD, Freedson PS, Chasan-Taber L. Estimating physical activity using the CSA accelerometer and a physical activity log. Med Sci Sports Exerc 2003; 35:1605-11.
90. Masse LC, Fuemmeler BF, Anderson CB, et al. Accelerometer data reduction: A comparison of four reduction algorithms on select outcome variables. Med Sci Sports Exerc 2005; 37:S544-S54.
91. Davis JN, Hodges VA, Gillham MB. Physical activity compliance: Differences between Overweight/Obese and normal-weight adults. Obesity 2006; 14: 2259-65.
92. Dinger MK, Behrens TK. Accelerometer-determined physical activity of free-living college students. Med Sci Sports Exerc 2006; 38: 774-9.
93. Schneider M, Dunn A, Cooper D. Affect, exercise, and physical activity among healthy adolescents. J Sport Exerc Psychol 2009; 31: 706-23.

94. Sallis JF, Saelens BE, Frank LD, et al. Neighbourhood built environment and income: Examining multiple health outcomes. Soc Sci Med 2009; 68: 1285-93.
95. Gabriel KP, McClain JJ, Schmid KK, et al. Isssus in accelerometer methodology: the role of epoch length on estimates of physical activity and relationships with health outcomes in overweight, post-menopausal women. Int J Behav Nutr Phys Act 2010; 7: 53
96. Hagstromer M, Troiano RP, Sjostrom M, et al. Levels and patterns of objectively assessed physical activity--a comparison between Sweden and the United States. Am J Epidemiol 2010; 171: 1055-64.
97. Troped PJ, Wilson JS, Matthews CE, et al. The Built Environment and Location-Based Physical Activity. Am J Prev Med 2010; 38:429-38.
98. Sirard JR, Forsyth A, Oakes JM, et al. Accelerometer test-retest reliability by data processing algorithms: results from the Twin Cities Walking Study. J Phys Act Health 2011; 8: 668-74.
99. Fuemmeler BF, Anderson CB, Masse LC. Parent-child relationship of directly measured
physical activity. Int J Behav Nutr Phys Act 2011; 8: 17.
100. McLoughlin MJ, Stegner AJ, Cook DB. The relationship between physical activity and brain responses to pain in fibromyalgia. J Pain 2011; 12: 640-51.
101. McLoughlin MJ, Colbert LH, Stegner AJ, et al. Are women with fibromyalgia less physically active than healthy women? Med Sci Sports Exerc 2011; 43: 905-12.
102. Ekelund U, Sepp H, Brage S, et al. Criterion-related validity of the last 7-day, short form of the International Physical Activity Questionnaire in Swedish adults. Public Health Nutr 2006; 9: 258-65.
103. Ekelund U, Brage S, Griffin SJ, et al. Objectively Measured Moderate- and Vigorous-Intensity Physical Activity but Not Sedentary Time Predicts Insulin Resistance in High-Risk Individuals. Diabetes Care 2009; 32:1081-6.
104. Hagstromer M, Ainsworth BE, Oja P, et al. Comparison of a Subjective and an Objective Measure of Physical Activity in a Population Sample. J Phys Act Health 2010; 7: 541-50.
105. Jago R, Fox KR, Page AS, et al. Parent and child physical activity and sedentary time: Do active parents foster active children? BMC Public Health 2010; 10: 194
106. Van Dyck D, Cerin E, Cardon G, et al. Physical activity as a mediator of the associations between neighborhood walkability and adiposity in Belgian adults. Health Place 2010; 16: 952-60.
107. Roman-Vinas B, Serra-Majem L, Hagstromer M, et al. International Physical Activity Questionnaire: Reliability and validity in a Spanish population. Eur J Sport Sci 2010; 10: 297-304.
108. Davis MG, Fox KR, Hillsdon M, et al. Objectively measured physical activity in a diverse sample of older urban UK adults. Med Sci Sports Exerc 2011; 43: 647-54.
109. Bratland-Sanda S, Sundgot-Borgen J. Symptoms of Eating Disorders, Drive for Muscularity and Physical Activity Among Norwegian Adolescents. Eur Eat Disord Rev. 2011 Sep 4. doi: 10.1002/erv.1156. [Epub ahead of print]
110. Baptista F, Santos DA, Silva AM, et al. Prevalence of the Portuguese Population Attaining Sufficient Physical Activity. Med Sci Sports Exerc 2012; 44: 466-73.
111. Hansen BH, Kolle E, Dyrstad SM, et al. Accelerometer-Determined Physical Activity in Adults and Older People. Med Sci Sports Exerc 2012; 44: 266-72.

112. Timperio A, Salmon J, Crawford D. Validity and reliability of a physical activity recall instrument among overweight and non-overweight men and women. J Sci Med Sport 2003; 6: 477-91.
113. Timperio A, Salmon J, Rosenberg M, et al. Do logbooks influence recall of physical activity in validation studies? Med Sci Sports Exerc 2004; 36: 1181-6.
114. Boon RM, Hamlin MJ, Steel GD, et al. Validation of the New Zealand Physical Activity Questionnaire (NZPAQ-LF) and the International Physical Activity Questionnaire (IPAQ-LF) with accelerometry. Br J Sports Med 2010; 44: 741-6
115. Sherar LB, Griew P, Esliger DW, Cooper AR, Ekelund U, Judge K, et al. International children's accelerometry database (ICAD): design and methods. *BMC Public Health*;11:485.
116. Hagstromer M, Troiano RP, Sjostrom M, Berrigan D. Levels and patterns of objectively assessed physical activity--a comparison between Sweden and the United States. *Am J Epidemiol*;171(10):1055-64.
117. Owen N, Healy GN, Matthews CE, Dunstan DW. Too much sitting: the population health science of sedentary behavior. *Exerc Sport Sci Rev* 2010;38(3):105-13.
118. Bauman A, Ainsworth BE, Sallis JF, Hagstromer M, Craig CL, Bull FC, et al. The descriptive epidemiology of sitting a 20-country comparison using the international physical activity questionnaire (IPAQ). *Am J Prev Med* 2011;41(2):228-35.
119. Levine JA, Lanningham-Foster LM, McCrady SK, Krizan AC, Olson LR, Kane PH, et al. Interindividual variation in posture allocation: possible role in human obesity. *Science* 2005;307(5709):584-6.
120. Guthold R, Cowan MJ, Autenrieth CS, Kann L, Riley LM. Physical activity and sedentary behavior among schoolchildren: a 34-country comparison. *J Pediatr*;157(1):43-49 e1.
121. Pratt M, et al. What works? Interventions for physical activity promotion around the world. *Lancet* 2011;(in press).
122. Assah FK, Ekelund U, Brage S, Mbanya JC, Wareham NJ. Urbanization, physical activity, and metabolic health in sub-Saharan Africa. *Diabetes Care*;34(2):491-6.
123. Sullivan R, Kinra S, Ekelund U, Bharathi AV, Vaz M, Kurpad A, et al. Socio-demographic patterning of physical activity across migrant groups in India: results from the Indian Migration Study. *PLoS One*;6(10):e24898.
124. Juneau CE, Potvin L. Trends in leisure-, transport-, and work-related physical activity in Canada 1994-2005. *Prev Med*;51(5):384-6.
125. Palacios-Cena D, Alonso-Blanco C, Jimenez-Garcia R, Hernandez-Barrera V, Carrasco-Garrido P, Pileno-Martinez E, et al. Time trends in leisure time physical activity and physical fitness in elderly people: 20 year follow-up of the spanish population national health survey (1987-2006). *BMC Public Health*;11(1):799.
126. Sjol A, Thomsen KK, Schroll M, Andersen LB. Secular trends in acute myocardial infarction in relation to physical activity in the general Danish population. *Scand J Med Sci Sports* 2003;13(4):224-30.
127. Stamatakis E, Chaudhury M. Temporal trends in adults' sports participation patterns in England between 1997 and 2006: the Health Survey for England. *Br J Sports Med* 2008;42(11):901-8.

128. Brownson RC, Boehmer TK, Luke DA. Declining rates of physical activity in the United States: what are the contributors? *Annu Rev Public Health* 2005;26:421-43.
129. Matsudo VK, Matsudo SM, Araujo TL, Andrade DR, Oliveira LC, Hallal PC. Time trends in physical activity in the state of Sao Paulo, Brazil: 2002-2008. *Med Sci Sports Exerc*;42(12):2231-6.
130. Hallal PC, Knuth AG, Rombaldi AJ, Malta DC, Iser BPM, Bernal RTI, et al. Time trends of physical activity in Brazil (2006-2009). *Rev Bras Epidemiol* 2011;(in press).
131. McDonald NC. Active transportation to school: trends among U.S. schoolchildren, 1969-2001. *Am J Prev Med* 2007;32(6):509-16.
132. Grize L, Bringolf-Isler B, Martin E, Braun-Fahrlander C. Trend in active transportation to school among Swiss school children and its associated factors: three cross-sectional surveys 1994, 2000 and 2005. *Int J Behav Nutr Phys Act*;7:28.
133. Buliung RN, Mitra R, Faulkner G. Active school transportation in the Greater Toronto Area, Canada: an exploration of trends in space and time (1986-2006). *Prev Med* 2009;48(6):507-12.
134. Ekelund U, Tomkinson G, Armstrong N. What proportion of youth are physically active? Measurement issues, levels and recent time trends. *Br J Sports Med* 2011;45(11):859-65.
135. Inoue S, Ohya Y, Tudor-Locke C, Tanaka S, Yoshiike N, Shimomitsu T. Time trends for step-determined physical activity among Japanese adults. *Med Sci Sports Exerc*;43(10):1913-9.
136. Sigmundova D, El Ansari W, Sigmund E, Fromel K. Secular trends: a ten-year comparison of the amount and type of physical activity and inactivity of random samples of adolescents in the Czech Republic. *BMC Public Health*;11:731.
137. Thompson AM, McHugh TL, Blanchard CM, Campagna PD, Durant MA, Rehman LA, et al. Physical activity of children and youth in Nova Scotia from 2001/02 and 2005/06. *Prev Med* 2009;49(5):407-9.
138. Raustorp A, Ludvigsson J. Secular trends of pedometer-determined physical activity in Swedish school children. *Acta Paediatr* 2007;96(12):1824-8.
139. World Health Organization. Global Strategy on Diet, Physical Activity and Health. Geneva: WHO, 2004.
140. Armstrong T, Bonita R. Capacity building for an integrated noncommunicable disease risk factor surveillance system in developing countries. *Ethn Dis* 2003;13(2 Suppl 2):S13-8.
141. Guthold R, Louazani SA, Riley LM, Cowan MJ, Bovet P, Damasceno A, et al. Physical activity in 22 African countries: results from the World Health Organization STEPwise approach to chronic disease risk factor surveillance. *Am J Prev Med* 2011;41(1):52-60.
142. Lee IM, Shiroma RL, Lobelo RF, Puska P, Blair SN, Katzmarzik PT. Public Health Consequences of Physical Inactivity. *Lancet* 2012;(in press).
143. Ainsworth BE, Macera CA, Jones DA, Reis JP, Addy CL, Bowles HR, et al. Comparison of the 2001 BRFSS and the IPAQ Physical Activity Questionnaires. *Med Sci Sports Exerc* 2006;38(9):1584-92.
144. Ekelund U, Sepp H, Brage S, Becker W, Jakes R, Hennings M, et al. Criterion-related validity of the last 7-day, short form of the International Physical Activity Questionnaire in Swedish adults. *Public Health Nutr* 2006;9(2):258-65.

145. Rzewnicki R, Vanden Auweele Y, De Bourdeaudhuij I. Addressing overreporting on the International Physical Activity Questionnaire (IPAQ) telephone survey with a population sample. *Public Health Nutr* 2003;6(3):299-305.
146. Lee PH, Macfarlane DJ, Lam TH, Stewart SM. Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): A systematic review. *Int J Behav Nutr Phys Act*;8(1):115.
147. Hallal PC, Gomez LF, Parra DC, Lobelo F, Mosquera J, Florindo AA, et al. Lessons learned after 10 years of IPAQ use in Brazil and Colombia. *J Phys Act Health*;7 Suppl 2:S259-64.
148. Bauman A, Ainsworth BE, Bull F, Craig CL, Hagstromer M, Sallis JF, et al. Progress and pitfalls in the use of the International Physical Activity Questionnaire (IPAQ) for adult physical activity surveillance. *J Phys Act Health* 2009;6 Suppl 1:S5-8.

Lancet Physical Activity Series Working Group

Jasem R Alkandari, Lars Bo Andersen, Adrian Bauman, Steven N Blair, Ross C Brownson, Fiona C Bull, Cora L Craig, Ulf Ekelund, Shifalika Goenka, Regina Guthold, Pedro C Hallal, William L Haskell, Gregory W Heath, Shigeru Inoue, Sonja Kahlmeier, Peter T Katzmarzyk, Harold W Kohl III, Vicky Lambert, I-Min Lee, Grit Leetongin, Felipe Lobelo, Ruth Loos, Bess Marcus, Brian Martin, Neville Owen, Diana C Parra, Michael Pratt, Pekka Puska, David Ogilvie, Rodrigo S Reis, James F Sallis, Olga Lucia Sarmiento, and Jonathan C K Wells

Acknowledgements

We would like to thank the following individuals for their valuable help in the data gathering and literature review for the present article: Valerie Lyn Clark, Hao Guo, Ken Hardman, Lisa Micklesfield, Andrea Torres.

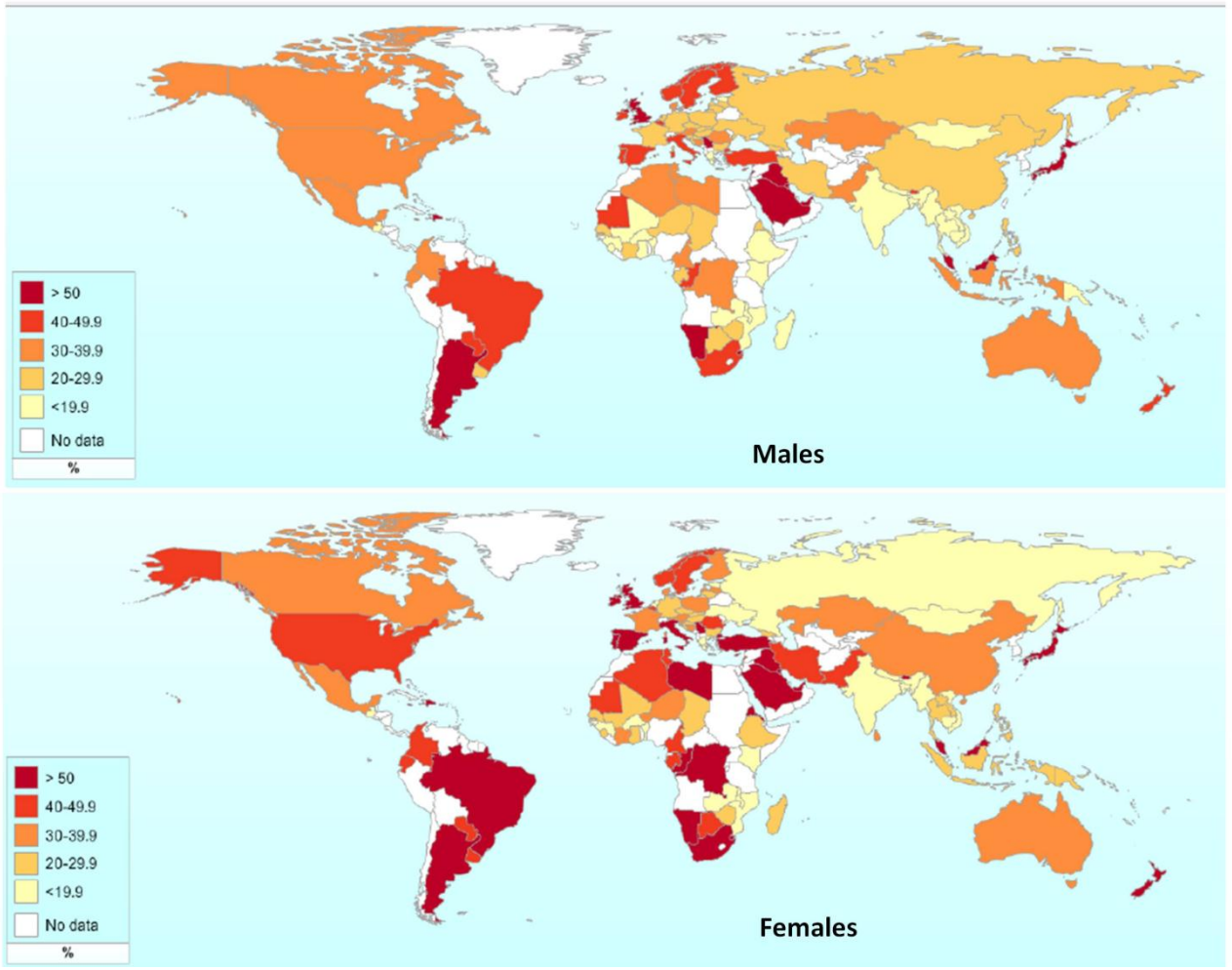

FIGURE 1. Prevalence of physical inactivity among adult (15 years or more) males and females worldwide.

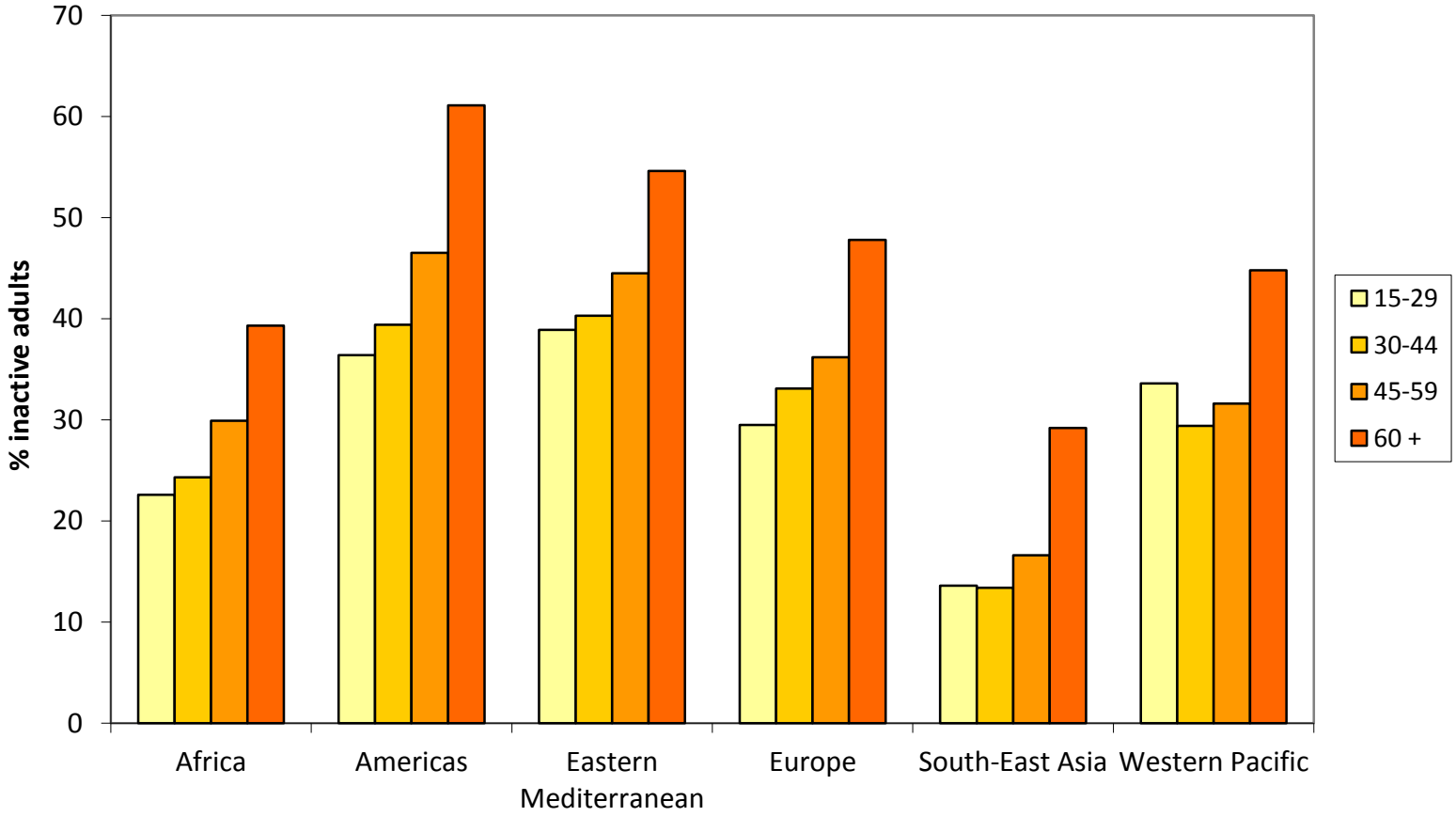

FIGURE 2. Prevalence of physical inactivity according to age categories across World Health Organization Regions.

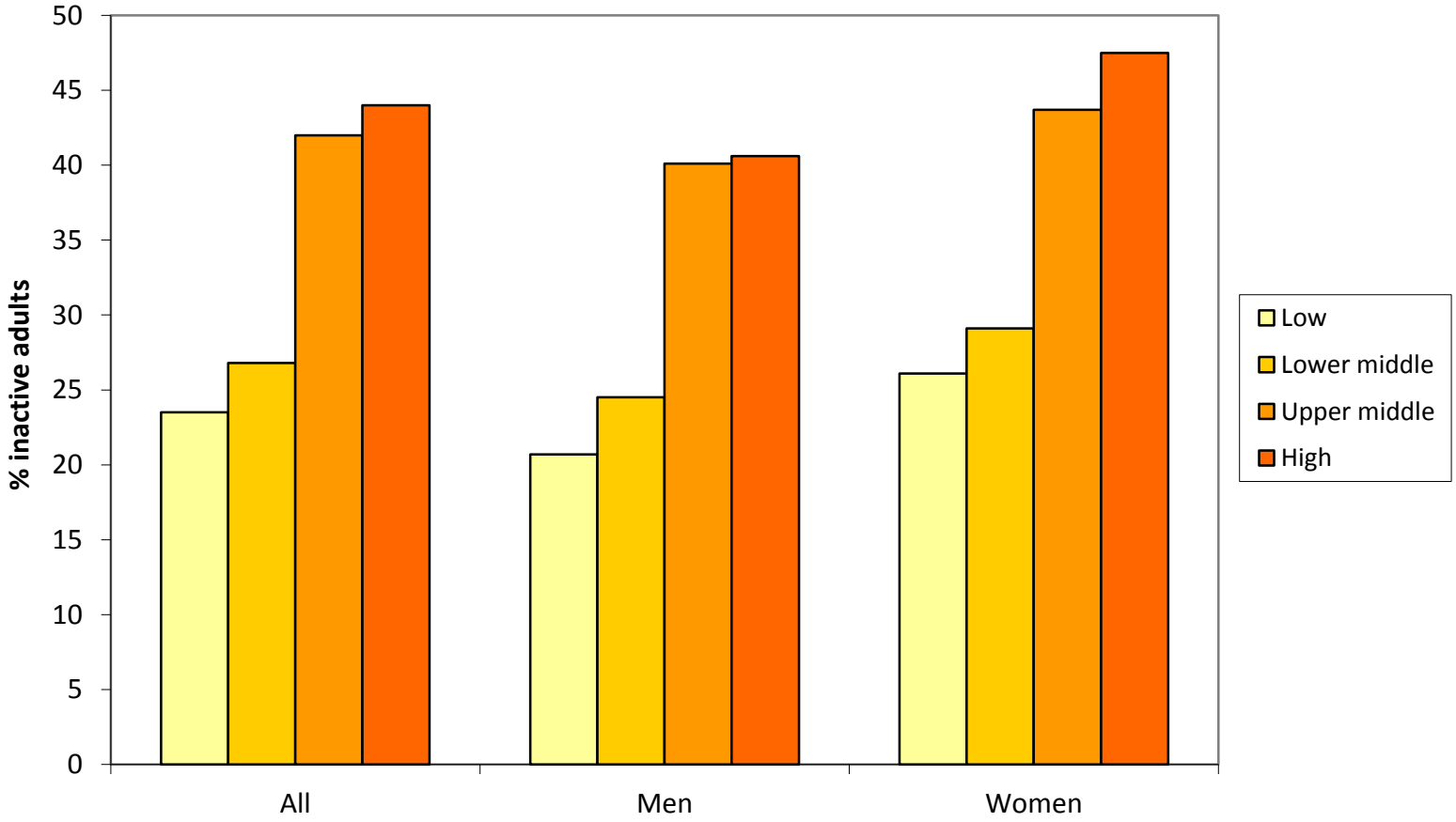

FIGURE 3. Prevalence of physical inactivity according to sex and World Bank income groups.

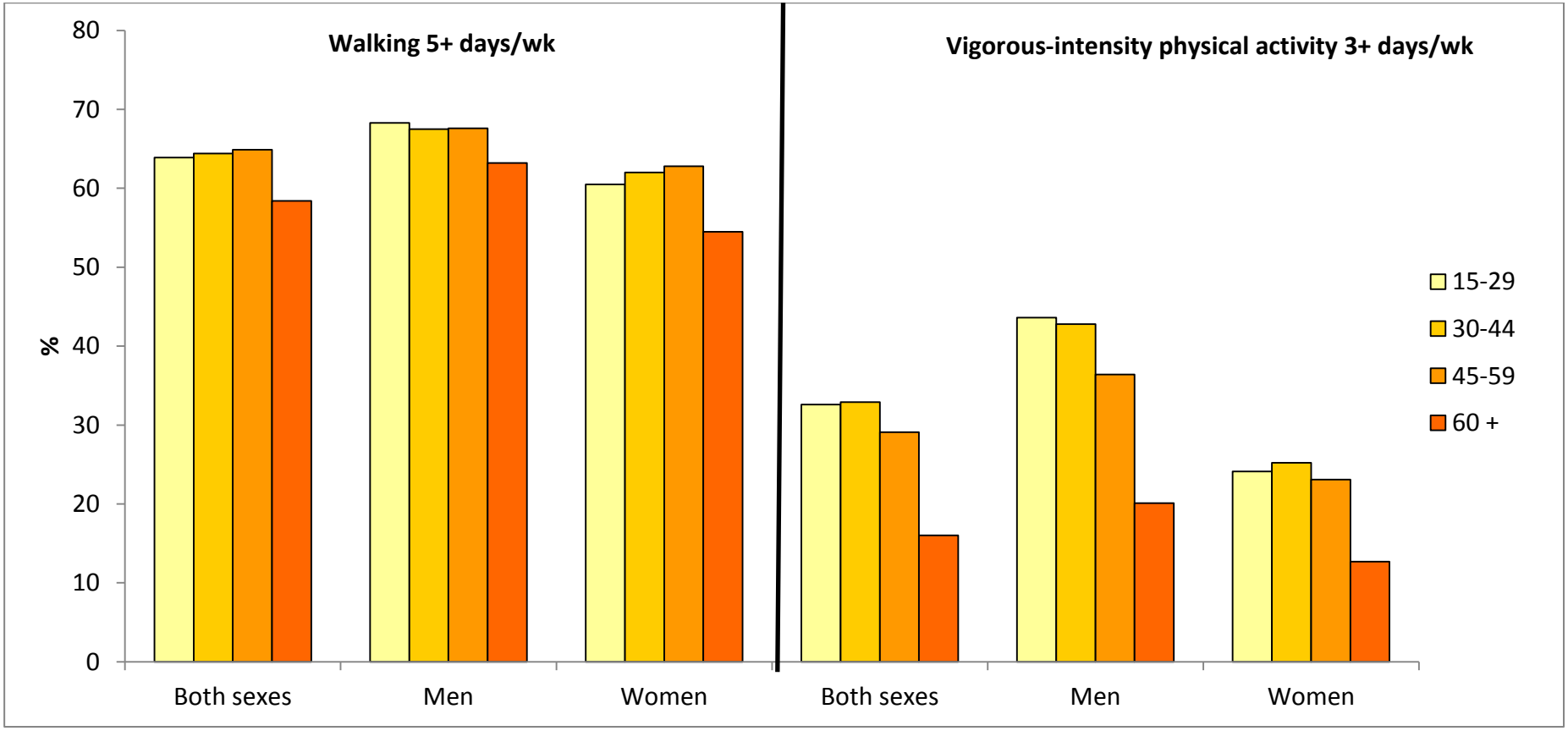

FIGURE 4. Proportion of individuals aged 15 years or more reporting five or more days of walking per week (left side of the figure) and three or more vigorous-intensity physical activity days per week (right side of the figure) across age categories.

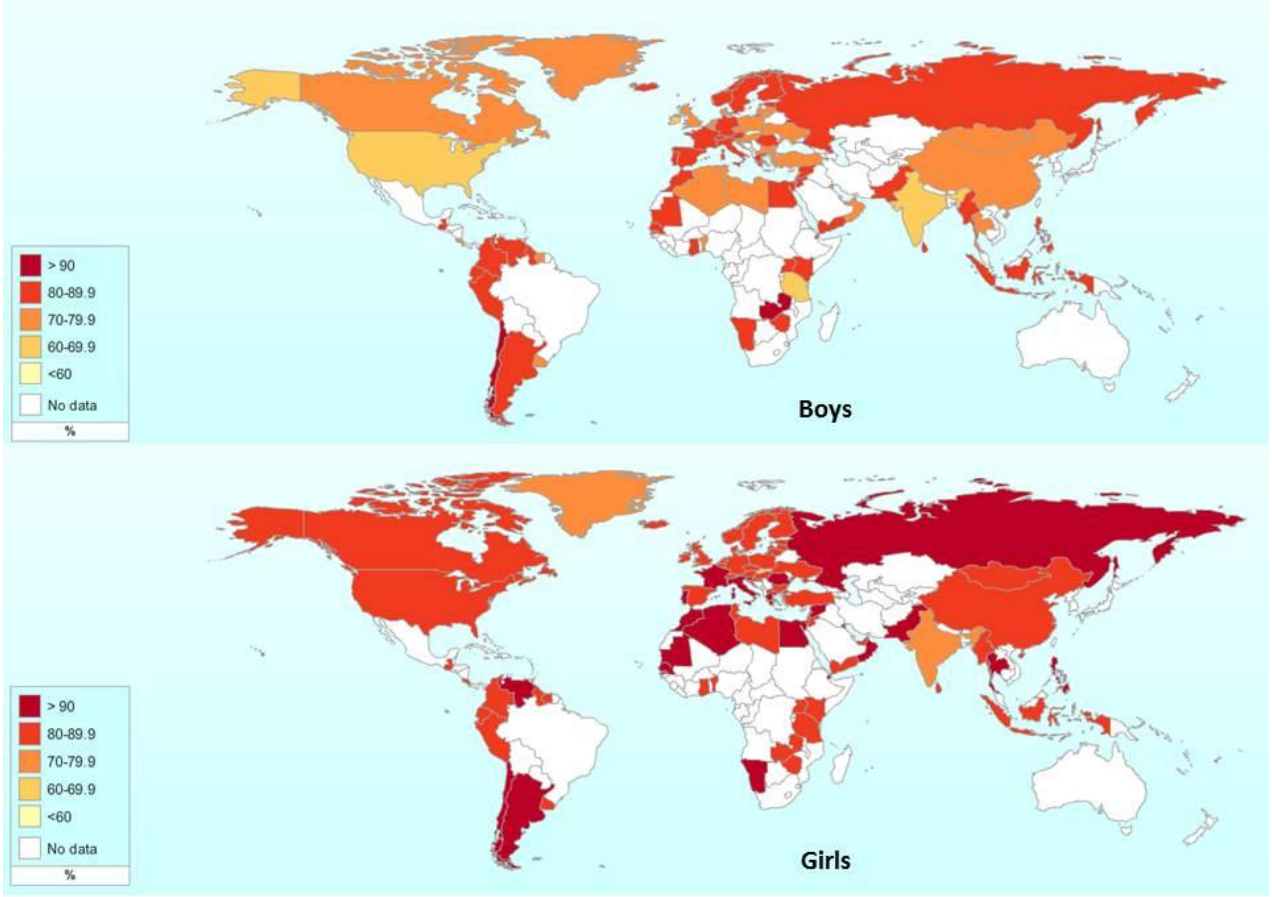

FIGURE 5. Proportion of 13-15 year-old adolescent boys and girls not achieving 60 minutes per day of moderate-to-vigorous physical activity practice.

TABLE 1. Proportion of adults reporting walking to work, cycling to work, or using any type of active transportation (walking or cycling) in studies from different countries.

Country	% walking to work	% cycling to work	% active transportation (walking or cycling)
Australia	3.8%	0.9-1.7%*	4.7%
Austria	5.0-6.6%*		
Brazil			11.9%
Canada	6.6%	1.0-1.2%*	
China	22.6%	23.5%	46.1%
Denmark		25.0%	
Finland			19.5%
France			34.9%
Germany	23.0%	9.0%	32.0%
Ireland	10.9%	1.9%	12.8%
New Zealand	7.0%	2.5%	
Switzerland	2.2%	0.3%	2.5%
Sweden	23.5%	9.5%	22.2-33.0%*
The Netherlands	12.1%	21.0-25.8%*	37.9%
United Kingdom	12.5%	2.0%	14.5%
United States	3.1-4.0%*	0.5-3.4%*	4.0%

* Interval reported for multiple studies or data collected in multiple states.

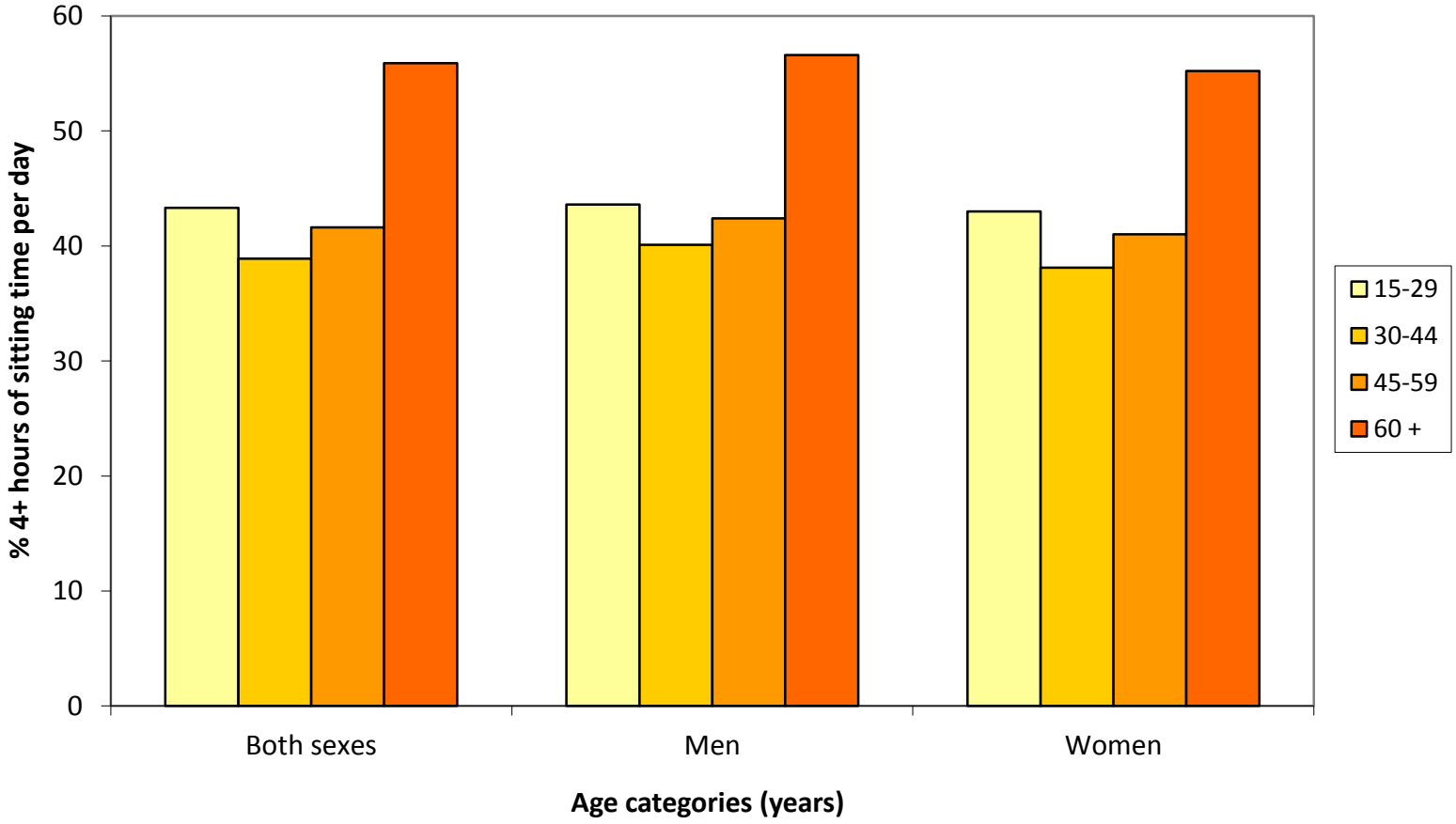

FIGURE 6. Proportion of individuals reporting four or more hours of sitting time per day across age categories.

Web appendix

ORIGINAL TEXT (330 WORDS)

To assess accelerometry data for moderate to vigorous physical activity in adults, we searched Medline and Web of Science for reports in which physical activity was measured by the Actigraph accelerometer. Our inclusion criteria were healthy adult participants older than 18 years, activity measured for at least 4 days and for at least 600 min per day, and a definition of moderate to vigorous physical activity of either 1952 or more or 2020 or more activity counts per min. When the same study was included in several reports, results from only one were extracted and included.

Overall, data from 34 reports from 13 countries and more than 19 000 individuals—were extracted. Data for length of activity from individual studies were combined with random effect meta-analysis by geographical region (Canada and the USA total n=6808, Europe n=9638, western Pacific n=725, and others n=1990). For young people, we used data from the international children's accelerometer database, which includes more than 30 000 individuals aged 4–18 years from 21 studies in ten countries. All raw accelerometer data files were reanalysed with the same data cleaning and data reduction criteria. For comparability with data for adults, moderate to vigorous physical activity was defined as more than 2000 counts per min, adjusted for sex and age.

For adults, the mean accumulated minutes of moderate to vigorous physical activity is about 37·5 min per day (95% CI 33·6–41–5; appendix). Mean time (min per day) spent in moderate to vigorous physical activity is significantly higher in adults from the western Pacific (Australia and New Zealand) region than in those from Canada and the USA, and Europe (p=0·0084), but adults from North America and Europe do not differ.

In young people, the highest amounts are done in Norway, Switzerland, Estonia, and Australia; values from Belgium, Brazil, and the USA were substantially lower than the pooled adjusted mean of roughly 65 min per day. Highly significant heterogeneity between countries was recorded (appendix).

NEW TEXT (329 WORDS)

To assess accelerometry data for moderate to vigorous physical activity in adults, we searched Medline and Web of Science for reports in which physical activity was measured by the Actigraph accelerometer. Our inclusion criteria were population based studies in healthy adult participants older than 18 years, activity measured for at least 4 days and for at least 600 min per day. All reports used the same definition of moderate to vigorous physical activity of 2020 or more activity counts per min. Two studies[1,2] were included in separate and combined reports[1,2,3], and subsequently only results from the combined report[3] were included. Data from four countries (Norway, Portugal, Sweden and the US)[3,4,5] including 9564 individuals were extracted. For young people, we used data from the international children's accelerometer database, which includes more than 30 000 individuals aged 4–18 years from 21 studies in ten countries. All raw accelerometer data files were reanalysed with the same data cleaning and data reduction criteria. For comparability with data for adults, moderate to vigorous physical activity was defined as more than 2000 counts per min, adjusted for sex and age.

For adults, the mean accumulated minutes of moderate to vigorous physical activity is about 33·5 min per day (95% CI 34·0–37·0) in men and 32·0 min per day (95% CI 23·5–40·4) in women. Mean time (min per day) spent in moderate to vigorous physical activity is remarkable similar in men, ranging between 33·0 min per day in the US and 37·5 min per day in Portugal. A wider variation, ranging between 19·0 min per day in the US and 44·6 min per day in Portugal was observed in women.

In young people, the highest amounts are done in Norway, Switzerland, Estonia, and Australia; values from Belgium, Brazil, and the USA were substantially lower than the pooled adjusted mean of roughly 65 min per day. Highly significant heterogeneity between countries was recorded (appendix).

References

1. Hagströmer M, Oja P, Sjöström M. Physical activity and inactivity in an adult population assessed by accelerometry. *Med Sci Sports Exerc*. 2007; **39**: 1502-8.
2. Troiano RP, Berrigan D, Dodd KW, Mâsse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc*. 2008; **40**: 181-8.

3. Hagströmer M, Troiano RP, Sjöström M, Berrigan D. Levels and patterns of objectively assessed physical activity--a comparison between Sweden and the United States. *Am J Epidemiol*. 2010; **171**: 1055-64.
4. Hansen BH, Kolle E, Dyrstad SM, Holme I, Anderssen SA. Accelerometer-determined physical activity in adults and older people. *Med Sci Sports Exerc*. 2012; **44**: 266-72.
5. Baptista F, Santos DA, Silva AM, et al. Prevalence of the Portuguese population attaining sufficient physical activity. *Med Sci Sports Exerc*. 2012; **44**: 466-73.