Published in final edited form as:
Obes Rev. 2012 August ; 13(8): 659–680. doi:10.1111/j.1467-789X.2011.00982.x.

Time Use and Physical Activity: A Shift Away from Movement across the Globe

Shu Wen Ng and **Barry Popkin**
Department of Nutrition, University of North Carolina at Chapel Hill

Abstract

Technology linked with reduced physical activity (PA) in occupational work, home/domestic work, and travel and increased sedentary activities, especially television viewing, dominates the globe. Using detailed historical data on time allocation, occupational distributions, energy expenditures data by activity, and time-varying measures of metabolic equivalents of task (MET) for activities when available, we measure historical and current MET by four major PA domains (occupation, home production, travel, and active leisure) and sedentary time among adults (> 18 years). Trends by domain for the United States (1965–2009), the United Kingdom (1961–2005), Brazil (2002–2007), China (1991–2009), and India (2000–2005) are presented. We also project changes in energy expenditure by domain and sedentary time (excluding sleep and personal care) to 2020 and 2030 for each of these countries. The use of previously unexplored detailed time allocation and energy expenditures and other datasets represents a useful addition to our ability to document activity and inactivity globally. Given the potential impact on weight gain and other cardiometabolic health risks, the differential declines in MET of activity and increases in sedentary time across the globe represents a major threat to global health.

Keywords

physical activity; sedentary; time use; United States; United Kingdom; Brazil; China; India

I. INTRODUCTION

Patterns and trends in energy imbalance have been adversely affected by shifts in stages of eating, drinking, and activity[1, 2]. These shifts have been occurring since Paleolithic time, but they appear to have accelerated to varying degrees in different regions of the world in the past century. A major component of this transition has been the shift in all domains of activity and inactivity patterns and energy expenditure. This has been operationalized in the SLOTH model, which incorporates the time and activity domains of sleep, leisure, occupation, transportation, and home-based activities[3]. This paper reviews data sources for fully documenting SLOTH patterns and trends and uses case studies for the United States (US), the United Kingdom (UK), Brazil, China, and India to provide an in-depth sense of patterns, trends, and future projections in each domain of activity and hours of sedentary behavior.

Corresponding author: Barry M. Popkin, W. R. Kenan Jr. Distinguished Professor, University of North Carolina, 123 W. Franklin Street, Chapel Hill, NC 27516, Tel: 919-966-1732, Fax: 919-966-9159, popkin@unc.edu.

Conflicts of interest: Nike, Inc., Global Access to Sport Initiative funded this work. The authors completed the manuscript independently with assistance of reviewers. SWN and BMP conceptualized and wrote the manuscript, and SWN conducted all analyses. Neither author has conflicts of interest with respect to this manuscript.

The health and functional benefits of being active are clear[4, 5] and extend to all segments of the population [6]. On the flip side, being inactive or sedentary has been shown to be a distinct risk factor independent of physical activity (PA), particularly weight gain from childhood to adulthood and mortality[7, 8]. Beyond structured leisure activity, however, transportation activity, such as walking and bicycling, can be equally beneficial[9]. Consistent walking over the transition from young to middle adulthood can reduce weight gain with clear dose effects[10]. Active transit is similarly associated with more favorable body mass index, waist circumference, and fitness, and transit incorporating cycling is related to lower lifetime cardiovascular disease (CVD) risk classification[11]. A systematic review [12] found dose-dependent reductions in CVD risk with higher walking duration, distance, energy expenditure, and pace. Studies in China show that activity related to transport, home production, and occupation activities[13–16] are negatively related to poor health outcomes and that overall shifts in PA are a significant cause of long-term increases in weight and obesity[17].

While it is clear that there are significant health consequences associated with PA and inactivity, measuring and monitoring the levels of activity at the population level across the broad spectrum of daily living domains have been limited. To date monitoring and recommendations have focused on leisure-time activities, including walking, biking, jogging, and sports;[5, 18] sedentariness, particularly television viewing and related behaviors (e.g., snacking while watching television);[19, 20] or total PA levels. Consequently, the key domains of occupational and domestic work have largely been ignored, with few exceptions[16, 21, 22].

Globally, monitoring PA levels tends to be limited to benchmarks in national or international PA recommendations or the International Physical Activity Questionnaire (IPAQ)[23]. The IPAQ-short has been used in surveys globally, including the World Health Organization (WHO) World Health Surveys,[24] and has been validated for a number of populations[25–27]. While useful in providing aggregate measures of the proportion of populations engaging in vigorous or moderate walking and sitting activities, the IPAQ-short does not provide good estimates of energy expenditure across domains. In fact one evaluation of the use of the IPAQ-short form in Colombia and Brazil found for leisure-time and transport activities the IPAQ-long needed to replace the short version[28]. The IPAQ-long provides more detailed information, distinguishing among work, home, travel, and leisure activities[23], but is rarely used[28]. As part of the STEPwise approach to chronic disease risk factor surveillance (STEPS), the WHO developed the Global Physical Activity Questionnaire (GPAQ) in 2003 to provide guidance to participating countries' health agencies monitoring chronic disease risk factors at a population level. The GPAQ, much like the IPAQ-long, asks about time spent in vigorous, moderate, light, and sitting movement in work, travel, and leisure times. Metabolic equivalents of task (MET), defined as the ratio of a person's working metabolic rate relative to his or her resting (basal) metabolic rate,[29] are then assigned. However, the IPAQ-long and the GPAQ only provide instructions for applying a standard MET value for each level of intensity within each domain for all countries,[30, 31] which may not be appropriate due to vast differences in technological advancements across countries.

Consequently, most PA measurements are limited to those captured using IPAQ, GPAQ, or national or international PA recommendations. Other data sources, especially the time allocation literature that measures activities across the key domains among all respondents over a significant period of time, provide unique options. Most surveys, however, specialize in particular domains or types of activity, and each survey collects data in a slightly different way, which makes analysis complex and piecemeal. The existing measures of PA are problematic on a number of counts. First, the variation in methods across surveys makes it difficult to combine data at the domain-specific level and across all domains, preventing researchers from understanding potential trade-offs and patterns of activity across domains over time. Second, although health effects are mainly tied to total activity (or inactivity) levels, interventions are highly specific to domains, and understanding the factors driving activity (or inactivity) levels in each domain can help identify promising interventions. Third, MET databases relate mainly to modern levels of technology[32], do not provide data on MET for many occupations for earlier periods of reduced access to time-saving technologies, and do not provide MET for labor-intensive occupations in rural and urban sectors in many lower-income regions.

This lack of historical and current data has meant that the long-term shifts and the relative speed of change in activity and inactivity across the globe have rarely been addressed in a rigorous manner[33]. For the US, the most complete study of PA is the review by Brownson et al.[34] that examines current patterns and long-term trends related to activity, employment, travel behavior, and TV viewing using an array of data sources relevant within each domain. Others have looked at domain-specific patterns and trends over time, such as in occupational energy expenditure using occupational codes[22, 35]. For China, research has been limited to the China Health and Nutrition Survey (CHNS), one of the few longitudinal surveys that include information on various domains of activity[15, 16, 36].

We attempt to improve on the limited existing work by estimating average energy expenditure in four specific domains of activity (occupation, domestic production, travel, and active leisure) and sedentary time among adults in the US, the UK, Brazil, China, and India over time. We use an array of longitudinal and cross-sectional datasets from these countries, selecting when possible those that are nationally representative. We use time use data to describe trends in energy expenditure in the four domains and sedentary time for male and female adults for the US, the UK, and China. For Brazil and India, we have only limited data on average time spent across various occupations, with additional measures of active leisure activity from one area of Brazil. Based on these trends, we project changes in energy expenditure from each of the four activity domains and sedentary time (excluding sleep) by 2020 and 2030 if nothing alleviates the situation.

II. DATA

In the appendix we outline the data sources available for estimating PA and inactivity over time for these five countries. Because there is a dearth of data that include comprehensive measures of PA across the various domains of daily living for much of the world, we turn to cross-country measures of time use along with estimates of the average energy expenditure for various activities of daily living.

A. Domain-specific time use measures

Multinational Time Use Study—The Multinational Time Use Study (MTUS), first developed in the early 1980s, harmonizes time use datasets collected in the early 1960s through the mid-1980s into a single dataset with common series of background variables and total time spent per day in 41 activities. The original MTUS allowed comparison of British time use data with the 1965 Szalai Multinational Time Budget Study and data from Canada and Denmark. The MTUS since has grown to encompass over 60 datasets from 22 countries, including the US and the UK.[31] The MTUS contains harmonized time use data for the US and the UK from the last five decades.

American Time Use Survey—We also used the American Time Use Survey (ATUS) collected by the US Bureau of Labor Statistics since 2003[37].

China Health and Nutrition Survey—The CHNS is not designed as a time use study, but it provides data on time use and level of effort and strenuousness of reported occupations and time spent on other domains of daily living. It is a nationwide survey following approximately 20,000 individuals from 228 communities in 9 provinces of China (Guangxi, Guizhou, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Liaoning, Shandong).[38] We used the 1991, 1993, 1997, 2000, 2004, 2006, and 2009 CHNS data for this study.

United Nations International Labour Organization—The United Nations (UN) International Labour Organization (ILO) compiles statistics produced by accredited national statistical institutions on labor issues. We obtained data on the hours spent per week by occupation code or economic activity for adults (total and by gender) and the proportion of adults in the various occupation codes or economic activities. The years with complete data that had a consistent methodology over time for Brazil were 2002–2007 and for India 2000–2005.

B. Sources of data on domain-specific energy requirements/intensity

Compendium of Physical Activities—The Compendium of Physical Activities was developed for use in epidemiological studies to standardize the assignment of MET intensities in PA questionnaires with updates over time (from 1993 to the 2011 version).[39, 40] The values in the compendium do not estimate the energy cost of PA in individuals in ways that account for differences in body mass, adiposity, age, sex, and efficiency of movement or geographic and environmental conditions in which the activities are performed. Thus individual differences in energy expenditure for the same activity can be large, and the true energy cost for an individual may or may not be close to the stated mean MET level. Rather, it is useful for providing a classification system that standardizes the MET intensities of PA used in survey research. Moreover, energy costs of certain activities (particularly occupational and some domestic work activities) are unlikely to be static over time with the introduction and popularity of new labor-saving technologies and machinery. Unfortunately, there are no earlier (pre-1990s) versions of the compendium. For this study, when we used the compendium, we applied the 1993 values for data from 1999 or earlier, and we applied the 2000 values for data from 2000 or later. Since none of our data is from 2011 onward, we did not use the 2011 compendium values. From a historical perspective it is important to note that the Food and Agricultural Organization of the United Nations (FAO-UN) led an earlier initiative to measure daily physical activity levels (PALs) as an important dimension of research to create energy intake requirements[41, 42]. This work represented the global state of the art for many decades.

Literature on energy expenditure—There are important complexities and limitations to use of the Compendium of Physical Activities for developing countries such as India, where the rural sector and parts of the urban sector engage in much more labor-intensive energy-expending activities than those sectors in other countries. Consequently, in the case of India, we turned to studies that estimated energy expenditures of men and women in rural and slum settings and compared developing and industrialized countries[43–47] across various occupational types, and we applied these to the India ILO data. In addition, for active leisure activity in Brazil (Sao Paolo), because the IPAQ-short questionnaire was used, we applied the recommended MET according to the IPAQ-short guidelines[30] rather than use the compendium. This approach does not allow us to create aggregate weighted averages of different components of active leisure for Brazil or India, and there are noted limitations to the IPAQ-short as discussed earlier[28]. Furthermore, energy expenditure varies with body weight; however we do not have a basis to use this to adjust the MET calculations to handle this shift over time.

C. Auxiliary data

World Bank World Development Indicators—The World Development Indicators (WDI) is the primary World Bank database for development data from officially recognized international sources.[48] We obtained data on the per capita gross domestic product (GDP) adjusted for purchasing power parity (PPP) for all five countries.

United Nations World Population Prospects—From the most recent release (May 2011) of the UN World Population Prospects we obtained data on the estimated (for 2010 and earlier) and projected (for 2011 and later) population sex ratio for the five countries.

III. METHODS

A. Estimating average energy expenditure and sedentary behavior across domains

China, United States, and United Kingdom—For China, the US, and the UK, we used measures of time spent in the various domains as one of the components that affect the energy expended in each of these domains, applied the appropriate estimated MET intensity values using the Compendium of Physical Activities based on the lowest level of detail available for each time use survey, and aggregated the various subdomain activities to get each individual's MET hours/week in each domain. In other words,

$$(Domain\ MET\ hrs\ per\ week)_{a,i}=\sum_{s=1}^{S} Time_{s,i} * MET_{s,i},\ \text{and}$$
$$(Total\ MET\ hrs\ per\ week)_{i}=\sum_{a=1}^{A} Domain\ MET\ hrs\ per\ week_{a,i},$$

where *i* denotes an individual, *a* denotes PA domains (occupational, domestic, travel, or active leisure), and *s* denotes subdomains (e.g., farming, food preparation, driving, playing basketball). In the case of sedentary behaviors (e.g., TV viewing, playing computer games), because there is substantial literature that shows strong associations between inactive time and negative health outcomes[7, 8], we looked at weekly sedentary time (excluding sleep and personal care, such as changing clothes and showering) but did not convert this into energy expenditure.

Brazil—We calculated average occupational PA by multiplying the hours spent per week for each occupation code or economic activity reported in the ILO statistics with the appropriate estimated MET intensity values using the Compendium of Physical Activities, weighted by the proportion of adults in the various occupation codes or economic activities. For active leisure activity, we used the 2002 and 2008 Sao Paolo Physical Activity Survey and applied the MET intensity values according to the IPAQ guidelines. For domestic and travel PA and sedentary time, we used the gender-specific average activity measures found in the US and China from periods of similar economic development (based on per capita GDP PPP) for each country (2002 Brazil to 1975 US and 2006 China; 2007 Brazil to 1985 US and 2009 China), weighted by the sex ratios for Brazil in 2002–2007, to derive these time-use measures.

India—We calculated average occupational PA by multiplying the hours spent per week for each occupation code or economic activity reported in the ILO statistics with the appropriate estimated MET intensity values found in the literature[43, 45, 46], weighted by the proportion of adults in the various occupation codes or economic activities. For domestic, travel, and active leisure PA and sedentary time, we used the gender-specific average activity measures found in China from periods of similar economic development (based on per capita GDP

PPP) for each country (2000 India to 1995 China; 2005 India to 2000 China), weighted by the sex ratios for India in 2000–2005, to derive these time-use measures

B. Forecasting into 2020 and 2030

We were interested in estimating what the levels of PA for each domain and sedentary time would look like in the future (in 2020 and 2030) if current trends regarding modernization and time use continue. An overarching assumption is that the trends over time are linear. For countries with a limited range of years of observed data (Brazil and India), we were limited to using the slope (or rate of change) in each domain of activity and sedentary time between the first and last year for forecasting into 2020 and 2030. For the countries with data that spanned more than five years, a number of slopes were possible, including:

- **a.** using the last two waves of data only (2008 and 2009 for the US, 2000 and 2005 for the UK, 2006 and 2009 for China),
- **b.** using the middle range of data only (2003 and 2009 for the US, 1995 and 2005 for the UK, 2004 and 2009 for China),
- **c.** using first and last years of data (1965 and 2009 for the US, 1961 and 2005 for the UK, 1991 and 2009 for China),
- **d.** using the annualized three-year moving averages.

We calculated forecasts using the various possible slopes as sensitivity analyses, keeping in mind that there is a lower threshold for total PA levels. Specifically, a person who sleeps all the time will still expend 151.2 MET hours/week, but since we have ignored sleep (which has stayed consistent over time at around 50 hours/week or 47 MET hours/week)[49] in our calculations, the lower threshold we are considering is around 104 MET hours/week. This provided a range of feasible forecasted PA levels and sedentary time for the US, the UK, and China.

IV. RESULTS

Table 1 summarizes our calculations for the rate of change for each of the five countries over time based on available data and their forecasted change in each domain of PA, total PA, and sedentary time for 2020 and 2030. While data were initially obtained by gender, weighted averages are used to present the average adult data in this table. We find that across all countries studied here, overall PA levels from the four domains of activity combined will continue on a downward trend and sedentary time will increase if lifestyle behaviors do not change. We report the estimates using different slopes in the appendix (appendix table 2). In general, the forecasts for total PA were robust across the various methods used for these countries.

United States

Figure 1 shows that in the US total PA from the four domains in 1965 was already somewhat low at 235 MET hours/week for adults, with occupational PA constituting the majority. Total PA actually rose slightly between 1987 and 1995 driven by occupational PA. Subsequently, it fell to 160 MET hours/week in 2009, and it is forecasted to be around 142 MET hours/week by 2020 and 126 MET hours/week by 2030 (see figure 1) due to declines in occupational, domestic, and travel PA. Our forecast shows that active leisure PA will have slight increases during this period. However, time spent in sedentary behaviors will continue to increase to nearly 42 hours/week by 2030.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

United Kingdom

Total PA in the UK in 1961 was even lower than in the US in 1965, 216 MET hours/week for adults, again with occupational PA constituting the majority. Total PA fell to 173 MET hours/week (20% decline) by 2005. Our forecasting shows that by 2020 total PA will sum to 153 MET hours/week and by 2030 to 140 MET hours/week. We anticipate slight increases in travel and active leisure PA but not enough to countervail the continued declines in occupational and domestic PA. Meanwhile, our forecast shows that sedentary leisure time will increase to over 51 hours/week by 2030.

Brazil

Our estimates for Brazil in figure 3 show that total PA was 229 MET hours/week in 2002, declined to 214 in 2008, and will continue to decrease to 180 and 151 MET hours/week in 2020 and 2030, respectively. The largest absolute decline is in occupational PA, but the largest relative decline is in domestic PA. Active leisure PA is expected to continue rising over time, but that increase based on trends to date will be insufficient to make up for declines in PA elsewhere. Sedentary time is projected to rise from 24 hours/week to 29 and 33 hours/week by 2020 and 2030, respectively.

China

Figure 4 shows that in China total PA from the four domains in 1991 was around 399 MET hours/week for adults, with occupational PA constituting the majority. Total PA fell to 213 MET hours/week by 2009 largely due to declines in occupational, domestic, and travel PA. Our forecast shows that total PA will be 200 MET hours/week by 2020 and 188 MET hours/week by 2030. We anticipate that declines in occupational PA will continue, albeit at a slower rate, along with declines in domestic PA, little change in travel PA, and slight absolute growth in active leisure PA. Time spent in sedentary behaviors will increase from about 20 hours/week in 2009 to 23 hours/week in 2020 and 25 hours/week in 2030.

India

Figure 5 shows that India is the most resistant to declines in PA among the five countries studied here, but even so there is a noticeable decrease, particularly in occupational PA, projected into 2030. At the same time sedentary time is expected to rise from 18.6 hours/week in 2000 to 20 hours/week by 2030.

V. CONCLUSIONS

A. Overview of results

Based on observed trends, PA is declining rapidly across the globe. It is particularly the case in China and Brazil, which have the two highest absolute and relative rates of decline in total PA and some of the higher increases in sedentary time. For these two countries, the declines in activity have been largely driven by reductions in movement at work, at home, and to a lesser degree in travel. This is not surprising given that in the past few decades the Chinese and Brazilians have been shifting away from agriculture into the manufacturing and service/tertiary sectors, have increased their use of machines and labor-saving technology in the workplace, and have greater access to home technologies (e.g., electrification, piped water, appliances) and vehicles. Our forecasts are bleak. For instance, by 2020 the average American adult will only expend 142 MET hours/week while awake. The British are only slightly better but will reach that level by 2030. The Chinese and Brazilians continue on their steeper downward trend, reaching the US and UK total PA levels by 2030. The situation in India appears less severe, but this average masks the stark socioeconomic dichotomy that will likely continue in India, with wealthier Indians leading lifestyles more like the average British (with possibly even lower domestic PA due to the prevalence of domestic maids among this subpopulation of India).

Our findings on PA in the US and the UK are consistent with earlier work by others who looked at specific domains[34, 49–51]. In the US and the UK second car ownership has increased, the distance walked per year has declined, and the vehicle miles traveled have increased[51–55]. The trend is less severe in the UK, where active transport is promoted and urban design is more conducive to walking and bicycling[46]. The increased sedentary time in the US, the UK, Brazil, and China could very well be because of the growth in media technologies (e.g., televisions, cable, computers, the Internet) as our results fit market research on television viewing[56].

India has yet to exhibit these trends, especially in the rural sector. While India's rising middle class has attained significant access to modern technology and the ability to hire domestic help, other segments of urban areas (including slums/squatter areas) and rural areas are barely touched by modern technology in most domains of daily living[43–46]. The Indian National Rural Employment Guarantee Act[57], which provides partial employment to unemployed adults, mainly involves manual labor (laying roads, digging wells, etc.) and will likely have an impact on the PA profile in rural areas.

Our time use data for the US, the UK, and China (see appendix figures 1–3) indicate distinct differences in the activity patterns of men and women, consistent with findings elsewhere[36], particularly in developing countries, where women typically hold the triple burden of child care/household production, reproduction, and occupational work[58]. For US women, time spent on domestic activities fell by one-third from 1965 and to 1995, from about 40 to 27 hours/week[59]. The opposite occurred for men overall, but there was a net reduction in time devoted to household and family care, with the decline in housework being the dominant explanatory factor. One of the more interesting time use shifts is the drop across the globe in food preparation time, very much related to the growth of processed food availability, which has resulted in a shift from about two hours/week to half an hour/week[60, 61].

B. Limitations

This review provides a descriptive look at the PA levels across the various domains of daily living over time in five countries to highlight the severity of the problem many nations will face in the near future. Our work here is limited by the data available, which were incomplete for India and Brazil. Only for the US, the UK, and China were we able to unify time use and MET data, and China was the only source based on longitudinal data. To estimate the changes in certain PA domains for India and Brazil we used trends from China and the US. In addition, the data used on the intensity of activities across domains are from relatively recent periods and so most likely have resulted in conservative estimates of the PA declines (particularly for occupational and domestic PA prior to the 1990s). Our forecasting also assumes linear trends to predict PA levels into the future and may not adequately account for potential demographic changes, future rates of economic development, and technological advancements.

A major limitation of all work on physical activity is the simplification of a very complex, heterogeneous set of activities by the use of METs and also aggregate measures [28]. Region, season, year, occupation and types of technology available play such important roles in explaining the metabolic effects of each activity [41, 42, 47, 62]. By compacting time allocation into broad groupings and by having a compendium with so few activities, it is important to understand the limitations of these trends in METs. This is particularly the case for another reason, the shift in technology and environments from the 1960s that represent major changes in energy expended at any task in the home or workplace (e.g., from churning butter or making chappatis or bread to toasting or heating the same item today and then applying store-bought butter). There is no central depository or collection of the thousands of studies on energy expenditure by task as there is for food composition tables—the equivalent of providing calories per 100 gram for food as METs provide measures of energy expenditures per minute or hour.

This paper does not discuss the major cultural, social, physical, and economic barriers that need to be addressed if behavior change is to be promoted in favor of increased PA or to discourage sedentary behavior[63]. Similarly, we have not described or discussed the social gradients that exist among different income or education groups within a country as they relate to PA or inactivity. While we discuss the role of technological advancements, urbanization, or globalization on the PA trends here, we have not implicitly modeled these relationships due to the lack of data across these countries. Lastly, we do not deal with all the important changes in other stages of the life cycle.

C. Implications

It is clear that there exist major gaps in measuring PA, sedentary behavior, and energy expenditure. Research on country- or context-specific measurement of MET for a vast array of activities exists, such as that we used for India[46, 64, 65], but it has never been pulled together in a complete reference volume. It would be enormously valuable to organize a searchable database of all the results of studies on energy expenditures across the globe to allow scholars to search and create context-specific MET values for an array of activities, most of which are measured in these time use surveys.

There is also a need for improved collaboration across national and international agencies to coordinate data collection on PA to represent both the various domains of daily living and measures of total activity and inactivity using objective measures (via pedometers or accelerometers). There have been some investments in this regard with the National Diet and Nutrition Survey (UK) and the National Health and Nutrition Examination Survey (US) now using objective assessments alongside self-reported PA measures. Continued investments to enhance the use of these complementary forms of measurements are needed if we are to better monitor the patterns of human movement and create policies or interventions that can be effective[66].

The policy side of changing PA patterns, particularly related to transportation, will have important benefits for pollution control and climate change concerns as well. Our work here shows slight increases in travel PA for the UK, but this rate of change needs to occur faster than currently projected toward the examples of other European countries, such as the Netherlands and Denmark[67]. In contrast, in the US there was no change in travel PA in the last decade. This needs to improve and requires integrated policies that include different but complementary interventions, infrastructure provision, supportive land use planning, and restrictions on car use[55, 68, 69]. Regulatory and taxation options for improving active travel exist. These range from congestion charging schemes to reduce car use, with a resultant increase in cycling and walking for transport and other positive outcomes, such as better air quality, lower noise pollution, and lower congestion[70], to a growing array of transportation options. However, without disincentives to car ownership and use along with improved mass transit, these changes will not occur. Brazil, China, and India are moving rapidly toward reduced travel PA along with growing vehicle ownership[71]. Slowing this down or turning it around will require a commitment to consider long-term health outcomes and environmental factors along with short-term economic growth.

Active leisure is a much more complex target. The literature on active leisure has been dominated by research from the US, the UK, Australia, and Brazil but is minimal for many other countries. The Agita Mundo initiative is exemplary for addressing movement in leisure and other modes[72–75]. However, to date the slight upward trends in active leisure in the UK, the US, and Brazil have been small in comparison to the large declines in PA from the other domains despite significant efforts and investments to encourage active leisure. These countries increasingly recognize that truly effective efforts to encourage active leisure will require taking safety, economic, personal, psychological, cultural, and social barriers into account[63]. Similarly, for the rest of the world, we need to identify culturally relevant approaches to active leisure activity across countries (e.g., traditional dancing, martial arts, soccer).

These forecasted declines in PA and increases in sedentary behavior will have significant implications for the health outcomes, health care costs, and overall functional well-being of societies across the globe. By focusing on these five countries that represent over 3 billion individuals (or almost 50% of the world's population), this study indicates what is expected if inaction continues in the face of rapid declines in PA and increases in sedentary behavior. It is our hope that the growing number of global initiatives and advocacy efforts in all regions of the world that are building momentum to study and intervene in all PA domains[18, 76] will be effective and that our estimates will never become reality.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The work presented in this paper was supported by funds from Nike, Inc., Global Access to Sport Initiative. We thank Drs. Victor Matsudo, K. Srinath Reddy, James F. Sallis, Nick Wareham, and Fei Xu for their helpful review and comments in earlier versions of this manuscript. We thank Drs. Rosangela Pereira and Rosely Sichieri for assistance in providing supporting data, Jim Terry and Dan Blanchette for exceptional assistance with data management and programming, Ms. Frances L. Dancy for administrative assistance, Mr. Tom Swasey for graphics support, and Nithya Gopu and Anne Cotleur, our liaisons with the Nike, Inc., Global Access to Sport Initiative team.

ACRONYMS AND ABBREVIATIONS

PA	physical activity
SLOTH	sleep, leisure, occupation, transportation, home-based activities
US	United States of America
UK	United Kingdom
CVD	cardiovascular disease
IPAQ	International Physical Activity Questionnaire
WHO	World Health Organization
STEPS	STEPwise approach to surveillance
GPAQ	Global Physical Activity Questionnaire
MET	metabolic equivalents of task
CHNS	China Health and Nutrition Survey
MTUS	Multinational Time Use Study
ATUS	American Time Use Survey

UN	United Nations
ILO	International Labour Organization
WDI	World Development Indicators
GDP	gross domestic product
PPP	purchasing power parity

References

1. Popkin BM, Adair Linda, Ng Shu Wen. Now and Then: The global nutrition transition: The pandemic of obesity in developing countries. Nutr Rev. In Press.
2. Popkin, BM. The World Is Fat--The Fads, Trends, Policies, and Products That Are Fattening the Human Race. New York: Avery-Penguin Group; 2008.
3. Pratt M, Macera CA, Sallis JF, O'Donnell M, Frank LD. Economic interventions to promote physical activity: application of the SLOTH model. Am J Prev Med. 2004; 27:136–145. [PubMed: 15450624]
4. U.S. Department of Health and Human Services. Physical Activity Guidelines Advisory Committee Report. US Department of Health and Human Services; 2008.
5. WCRF/AICR. AICR. Food, Nutrition, Physical Activity, and the Prevention of Cancer: A Global Perspective. World Cancer Research Fund/American Institute for Cancer Research; Washington, DC: 2007.
6. Rees DI, Sabia JJ. Exercise and adolescent mental health: new evidence from longitudinal data. J Mental Health Policy Econ. 2010; 13:13–25.
7. Dunstan DW, Thorp AA, Owen N, Neuhaus M. Sedentary behaviors and subsequent health outcomes in adults a systematic review of longitudinal studies, 1996–2011. Am J Prev Med. 2011; 41:207–215. [PubMed: 21767729]
8. Owen N, Healy GvN, Matthews CE, Dunstan DW. Too Much Sitting: The population health science of sedentary behavior. Exerc Sport Sci Rev. 2010; 38:105–13. [PubMed: 20577058]
9. Sallis JF, Frank LD, Saelens BE, Kraft MK. Active transportation and physical activity: opportunities for collaboration on transportation and public health research. Transportation Research Part A: Policy and Practice. 2004; 38:249–68.
10. 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; 169:1216–1223. [PubMed: 19597071]
11. Boone-Heinonen J, Jacobs DR Jr, Sidney S, Sternfeld B, Lewis CE, Gordon-Larsen P. A walk (or cycle) to the park: active transit to neighborhood amenities, the CARDIA study. Am J Prev Med. 2009; 37:285–292. [PubMed: 19765499]
12. Boone-Heinonen J, Evenson KR, Taber DR, Gordon-Larsen P. Walking for prevention of cardiovascular disease in men and women: a systematic review of observational studies. Obes Rev. 2009; 10:204–217. [PubMed: 19207874]
13. Bell AC, Ge K, Popkin BM. The road to obesity or the path to prevention: motorized transportation and obesity in China. Obes Res. 2002; 10:277–283. [PubMed: 11943837]
14. Bell AC, Ge K, Popkin BM. Weight gain and its predictors in Chinese adults. Int J Obes Relat Metab Disord. 2001; 25:1079–1086. [PubMed: 11443510]
15. Monda KL, Gordon-Larsen P, Stevens J, Popkin BM. China's transition: the effect of rapid urbanization on adult occupational physical activity. Soc Sci Med. 2007; 64:858–870. [PubMed: 17125897]
16. Monda KL, Adair LS, Zhai F, Popkin BM. Longitudinal relationships between occupational and domestic physical activity patterns and body weight in China. Eur J Clin Nutr. 2008; 62:1318–1325. [PubMed: 17637599]
17. Ng SW, Norton E, Guilkey D, Popkin BM. Estimation of a dynamic model of weight. Empirical Econ. In press.

18. World Health Organization. Global Strategy on Diet, Physical Activity and Health: Obesity and Overweight. 2004.
19. Epstein LH, Saelens BE, Myers MD, Vito D. Effects of decreasing sedentary behaviors on activity choice in obese children. Health Psychol. 1997; 16:107–113. [PubMed: 9269880]
20. Dietz WH, Gortmaker SL. Preventing obesity in children and adolescents. Annu Rev Public Health. 2001; 22:337–353. [PubMed: 11274525]
21. Lanningham-Foster L, Nysse LJ, Levine JA. Labor saved, calories lost: the energetic impact of domestic labor-saving devices. Obes Res. 2003; 11:1178–1181. [PubMed: 14569042]
22. Church TS, Thomas DM, Tudor-Locke C, et al. Trends over 5 decades in U.S. occupation-related physical activity and their associations with obesity. PloS one. 2011; 6:e19657. [PubMed: 21647427]
23. IPAQ Group. questionnaire O. International Physical Activity Questionnaire. online
24. WHO. World Health Survey. WHO; Geneva:
25. Bauman A, Bull F, Chey T, et al. The International Prevalence Study on Physical Activity: results from 20 countries. Int J Behav Nutr Physical Activity. 2009; 6:1–11.
26. Craig CL, Marshall AL, Sjostrom M, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc. 2003; 35:1381–1395. [PubMed: 12900694]
27. Guthold R, Ono T, Strong KL, Chatterji S, Morabia A. Worldwide Variability in Physical Inactivity: A 51-Country Survey. Am J Prev Med. 2008; 34:486–494. [PubMed: 18471584]
28. Hallal PC, Gomez LF, Parra DC, et al. Lessons learned after 10 years of IPAQ use in Brazil and Colombia. J Physical Activity Health. 2010; 7 (Suppl 2):S259–S264.
29. Sallis JF, Haskell WL, Wood PD, et al. Physical activity assessment methodology in the Five-City Project. Am J Epidemiol. 1985; 121:91–106. [PubMed: 3964995]
30. IPAQ Group. Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) -- Short and Long Forms. IPAQ Group; 2005.
31. Multinational Time Use Study. Versions World 5.5.3, 5.80 and 6.0 (released October 2010). Created by Jonathan Gershuny and Kimberly Fisher, with Evrim Altintas, Alyssa Borkosky, Anita Bortnik, Donna Dosman, Cara Fedick, Tyler Frederick, Anne H. Gauthier, Sally Jones, Jiweon Jun, Aaron Lai, Qianhan Lin, Tingting Lu, Fiona Lui, Leslie MacRae, Berenice Monna, José Ignacio Giménez Nadal, Monica Pauls, Cori Pawlak, Andrew Shipley, Cecilia Tinonin, Nuno Torres, Charlemaigne Victorino, and Oiching Yeung. University of Oxford, UK: Centre for Time Use Research online.
32. Ainsworth BE, Haskell WL, Herrmann SD, et al. 2011 compendium of physical activities: A second update of codes and MET Values. Med Sci Sports Exerc. 2011; 43:1575–1581. [PubMed: 21681120]
33. Corder K, van Sluijs EM. Invited commentary: comparing physical activity across countries--current strengths and weaknesses. Am J Epidemiol. 2010; 171:1065–1068. [PubMed: 20406761]
34. Brownson RC, Boehmer TK, Luke DA. Declining rates of physical activity in the United States: What are the contributors? Ann Rev Public Health. 2005; 26:421–443. [PubMed: 15760296]
35. Lakdawalla D, Philipson T. The growth of obesity and technological change. Econ Hum Biol. 2009; 7:283–293. [PubMed: 19748839]
36. Ng SW, Norton E, Popkin BM. Why have physical activity levels declined among Chinese adults? Findings from the 1991–2006 China health and nutrition surveys. Soc Sci Med. 2009; 68:1305–1314. [PubMed: 19232811]
37. Bureau of Labor Statistics. American Time Use Survey. US Bureau of Labor Statistics; 2003–2009. http://wwwblsgov/tus/
38. Popkin BM, Du S, Zhai F, Zhang B. Cohort Profile: The China Health and Nutrition Survey--monitoring and understanding socio-economic and health change in China, 1989–2011. Int J Epidemiol. 2009; 39:1435–1440. [PubMed: 19887509]
39. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of Physical Activities: an update of activity codes and MET intensities. Med Sci Sports Exerc. 2000; 32:S498–S516. [PubMed: 10993420]

40. Ainsworth BE, Haskell WL, Herrmann SD, et al. Compendium of Physical Activities: a second update of codes and MET values. Med Sci Sports Exerc. 2011; 43:1575–1581. [PubMed: 21681120]
41. Swinburn BA, Sacks G, Lo SK, et al. Estimating the changes in energy flux that characterize the rise in obesity prevalence. Am J Clin Nutr. 2009; 89:1723–1728. [PubMed: 19369382]
42. Swinburn BA, Jolley D, Kremer PJ, Salbe AD, Ravussin E. Estimating the effects of energy imbalance on changes in body weight in children. Am J Clin Nutr. 2006; 83:859–863. [PubMed: 16600939]
43. Dugas LR, Harders R, Merrill S, et al. Energy expenditure in adults living in developing compared with industrialized countries: a meta-analysis of doubly labeled water studies. Am J Clin Nutr. 2011; 93:427–441. [PubMed: 21159791]
44. Edmundson WC, Edmundson SA. Food intake and work allocation of male and female farmers in an impoverished Indian village. Br J Nutr. 1988; 60:433–439. [PubMed: 3219314]
45. Sujatha T, Shatrugna V, Vidyasagar P, et al. Timed activity studies for assessing the energy expenditure of women from an urban slum in south India. Food Nutr Bull. 2003; 24:193–199. [PubMed: 12891823]
46. Sujatha T, Shatrugna V, Venkataramana Y, Begum N. Energy expenditure on household, childcare and occupational activities of women from urban poor households. Br J Nutr. 2000; 83:497–503. [PubMed: 10953674]
47. Vaz M, Karaolis N, Draper A, Shetty P. A compilation of energy costs of physical activities. Public Health Nutr. 2005; 8:1153–8113. [PubMed: 16277826]
48. World Bank. World Bank Indicators. World Bank; online
49. Cutler D, Glaeser E, Shapiro J. Why have Americans become more obese? J Econ Perspectives. 2003; 17:93–118.
50. Gordon-Larsen P, Nelson MC, Beam K. Associations among active transportation, physical activity, and weight status in young adults. Obes Res. 2005; 13:868–875. [PubMed: 15919840]
51. Wareham N. Physical activity and obesity prevention. Obes Rev. 2007; 8:109–114. [PubMed: 17316312]
52. Millard-Ball A, Schipper L. Are we reaching peak travel? Trends in passenger transport in eight industrialized countries. Transport Rev. 2011; 31:357–378.
53. Brownson RC, Boehmer TK, Luke DA. Declining rates of physical activity in the United States: What are the contributors? Ann Rev Public Health. 2005; 26:421–443. [PubMed: 15760296]
54. Transportation Research Board, Institute of Medicine. TRB Special Report. Vol. 282. National Academies of Science; Washington DC: 2005. Does the Built Environment Influence Physical Activity? Examining the Evidence.
55. Brownson, R.; Boehmer, T. TRB Special Report 282 Does The Built Environment Influence Physical Activity? Examining The Evidence - Background paper. 2005. Patterns and trends in physical activity, occupation, transportation, land use, and sedentary behaviors.
56. The Nielsen Company. Global Television Audience Measurement. The Nielsen Company; 2010. How people watch: A Global Nielsen Consumer Report.
57. National Portal Content Management Team. National Rural Employment Guarantee Act. 2011.
58. McGuire J, Popkin BM. Beating the zero sum game: Women and nutrition in the Third World. Food Nutr Bull. 1989; 11:38–63.
59. Robinson JP, Godbey G. Trend, gender, and status differences in Americans' perceived stress. Loisir & Societe-Society and Leisure. 1998; 21:473–489.
60. Evenson, RE.; Popkin, BM.; King-Quizon, E. Nutrition, work and demographic behavior in rural Pilippines households. In: Binswanger, HP.; Evenson, RE.; Florencio, CA.; White, BNF., editors. Rural Households Studies in Asia. Singapore University Press; Singapore: 1980. p. 289-366.
61. Szalai, A.; Petrella, R. Cross-national comparative survey research : theory and practice. Oxford ; New York: Pergamon Press; 1977.
62. Vaz M, Bharathi AV, Thomas T, Yusuf S, Kurpad AV. The repeatability of self reported physical activity patterns in rural South India. Asia Pac J Clin Nutr. 2009; 18:71–75. [PubMed: 19329398]

63. Sallis JF, Cervero RB, Ascher W, Henderson KA, Kraft MK, Kerr J. An ecological approach to creating active living communities. Ann Rev Public Health. 2006; 27:297–322. [PubMed: 16533119]
64. Nag PK, Nag A. Drudgery, accidents and injuries in Indian agriculture. Ind Health. 2004; 42:149–162. [PubMed: 15128164]
65. Rao S, Gokhale M, Kanade A. Energy costs of daily activities for women in rural India. Public Health Nutr. 2008; 11:142–150. [PubMed: 17565761]
66. Lubans DR, Hesketh K, Cliff DP, et al. A systematic review of the validity and reliability of sedentary behaviour measures used with children and adolescents. Obes Rev. 2011; 12:781–799. [PubMed: 21676153]
67. Pucher J, Buehler R. Making cycling irresistible: Lessons from the Netherlands, Denmark and Germany. Transport Rev. 2008; 28:495–528.
68. 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; 100:1986–1992. [PubMed: 20724675]
69. Pucher J, Dill J, Handy S. Infrastructure, programs, and policies to increase bicycling: An international review. Prev Med. 2010; 50:S106–S25. [PubMed: 19765610]
70. de Nazelle A, Nieuwenhuijsen MJ, Anto JM, et al. Improving health through policies that promote active travel: a review of evidence to support integrated health impact assessment. Environ Int. 2011; 37:766–777. [PubMed: 21419493]
71. Pucher J, Peng ZR, Mittal N, Zhu Y, Korattyswaroopam N. Urban transport trends and policies in China and India: Impacts of rapid economic growth. Transport Rev. 2007; 27:379–410.
72. Matsudo V. The “Agita Sao Paulo” experience in promoting physical activity. West Indian Med J. 2002; 51 (Suppl 1):48–50. [PubMed: 12050975]
73. Matsudo V, Matsudo S, Andrade D, et al. Promotion of physical activity in a developing country: the Agita Sao Paulo experience. Public Health Nutr. 2002; 5:253–261. [PubMed: 12027292]
74. Monteiro CA, Conde WL, Matsudo SM, Matsudo VR, Bonseñor IM, Lotufo PA. A descriptive epidemiology of leisure-time physical activity in Brazil, 1996–1997. Revista Panamericana de Salud Publica. 2003; 14:246–254. [PubMed: 14662075]
75. JPAH Special Issue. Physical Activity Research in Latin America. J Phys Act Health. 2010; 7:S129–S278. [PubMed: 20702899]
76. Global Advocacy for Physical Activity, International Society for Physical Activity and Health. Non-communicable disease prevention: Investments that work for physical activity. 2011.

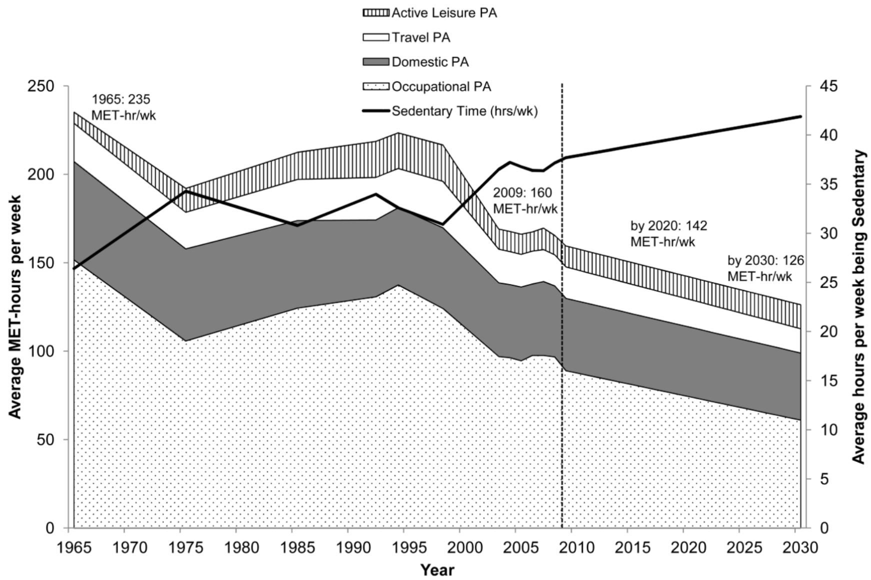

Figure 1.
US Adults MET-hours Per Week of All Physical Activity, and Hours/Week of Time in Sedentary Behavior: Measured for 1965–2009, Forecasted for 2010–2030
Source: Multinational Time Use Studies v.5.52 (1965, 1975, 1998) v.5.8 (1985, 1992, 1995), and American Time Use Survey 2003–2009; Applying Compendium of Physical Activity MET-intensity values based on reported time spent across 41 MTUS coded activities and by occupation. Forecasting for 2010–2030 based on 2003–2009 slopes.

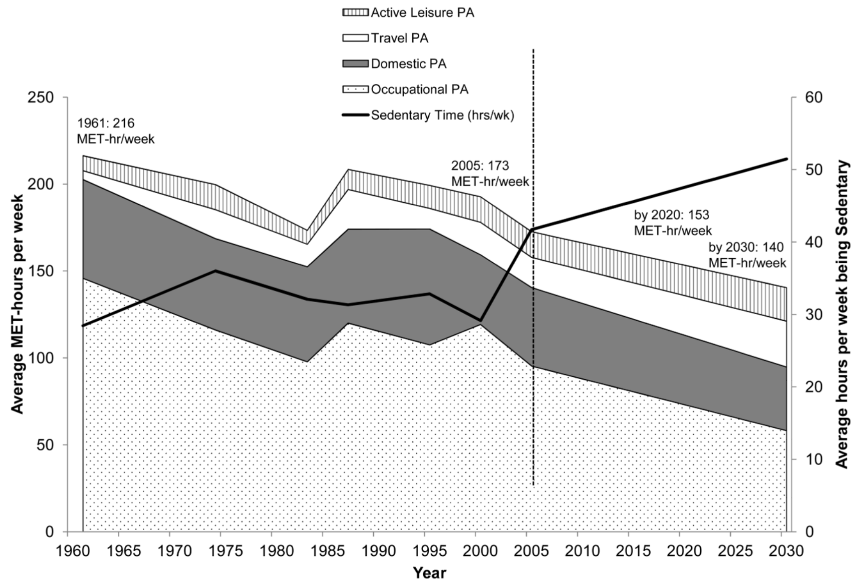

Figure 2.

UK Adults MET-hours Per Week of All Physical Activity, and Hours/Week of Time in Sedentary Behavior: Measured for 1961–2005, Forecasted for 2006–2030

Source: Multinational Time Use Studies v.5.52 (1961, 1983, 1987), and v.5.8 (1974, 1995, 2000, 2005); Applying the Compendium of Physical Activity MET-intensity values based on reported time spent across 41 MTUS coded activities and by occupation. Forecasting for 2006–2030 based on 1961–2005 slopes.

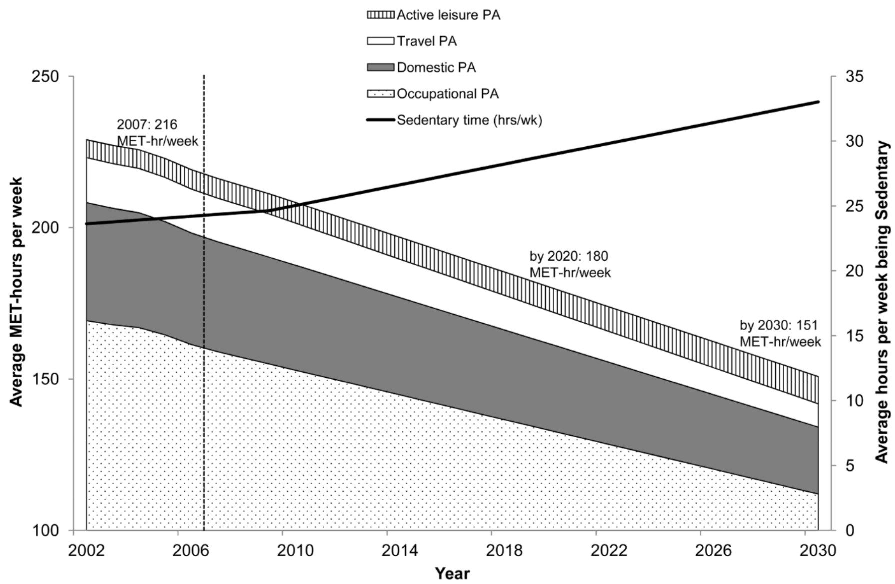

Figure 3.

Brazilian Adults MET-hours Per Week of All Physical Activity, and Hours/Week of Time in Sedentary Behavior: Measured for 2002–2007, Forecasted for 2009–2030

Source: Occupational PA based on 2002–2007 UN-ILO statistics applying MET-intensity values from the Compendium of PA. Active Leisure measure is from Sao Paolo, Brazil Physical Activity Study; applying the following MET-intensity value following the IPAQ guidelines: walking = 3.3 MET/hr; moderate only = 4 METs/hr; vigorous only = 8 METs/hr. All other energy expenditure and sedentary time values are estimated from applying the average activity measures found in the US and China from periods of similar economic development (based on per capita GDP PPP) for each of these countries (2002 Brazil to 1975 US and 2006 China; 2008 Brazil to 1985 US and 2009 China). Forecasting for 2009–2030 based on 2002–2007 slopes.

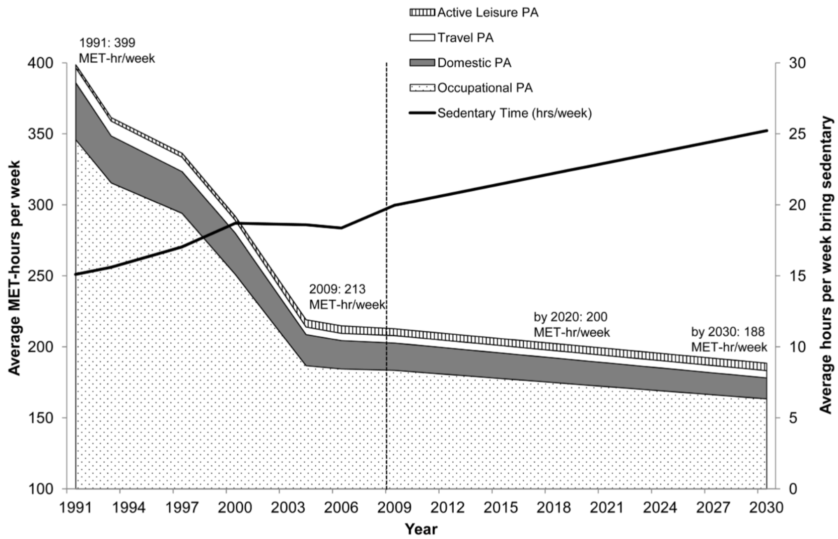

Figure 4.

Chinese Adults MET-hours Per Week of All Physical Activity, and Hours/Week of Time in Sedentary Behavior: Measured for 1991–2009, Forecasted for 2010–2030

Source: China Health and Nutrition Surveys 1991, 1993, 1997, 2000, 2004, 2006, 2009; Applying Compendium of Physical Activity MET-intensity values based on reported time spent in various activity sub-domains and by occupation. Forecasting for 2010–2030 is based on moving averages.

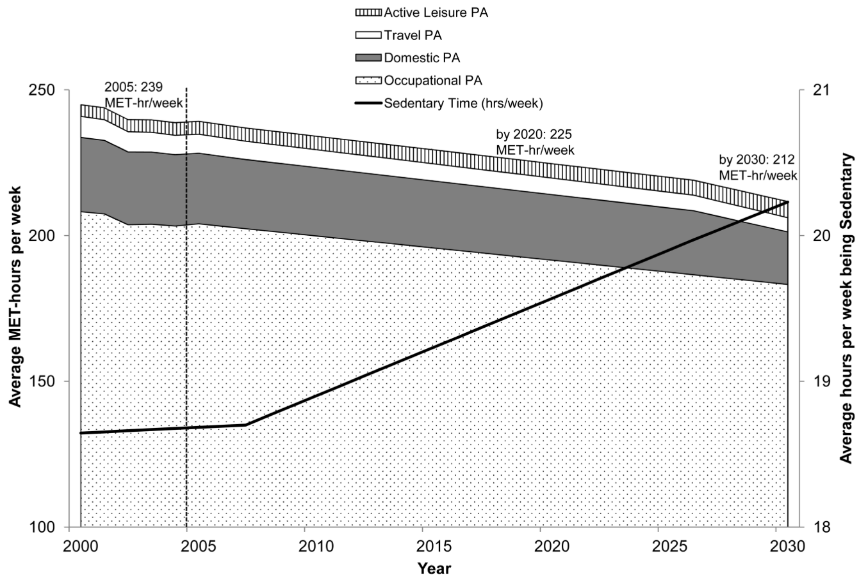

Figure 5.

Indian Adults MET-hours Per Week of All Physical Activity, and Hours/Week of Time in Sedentary Behavior: Measured for 2000–2005, Forecasted for 2006–2030

Source: Occupational PA based on 2000–2005 UN-ILO statistics applying the following MET-intensity values based on proportion of population residing in urban vs. rural areas based on past research estimating the energy expenditure for specific activities in India across different populations. All other energy expenditure and sedentary time values are estimated from applying the average activity measures found in China from periods of similar economic development (based on per capita GDP PPP) for each of these countries (2000 India to 1995 China; 2005 India to 2000 China). Forecasting for 2006–2030 based on 2000–2005 slopes.

Active Leisure PA Travel PA Domestic PA Occupational PA Sedentary Time

Table 1

Observed and forecasted changes in Occupational, Domestic, Travel and Active Leisure activity, and time being sedentary

		US[☼]	UK[☼]	Brazil [*€]	China [¥]	India [*‡]
Observed	**Years of data available (t1 to t2) Interval length**	**1965 to 2009 34 years**	**1961 to 2005 34 years**	**2002 to 2007 5 years**	**1991 to 2009 18 years**	**2000 to 2005 5 years**
weekly at t1	Occupational PA (MET-hrs/wk)	151.7	145.8	169.3	345.8	208.2
	Domestic PA (MET-hrs/wk)	55.6	56.8	39.0	40.1	25.5
	Travel PA (MET-hrs/wk)	21.7	5.1	14.8	10.6	7.2
	Active Leisure PA (MET-hrs/wk)	6.3	8.6	5.9	2.2	4.0
	Total PA (MET-hrs/wk)	235.2	216.4	229.0	385.9	244.9
	Being sedentary (hrs/wk)	26.4	28.4	23.6	15.1	18.6
weekly at t2	Occupational PA (MET-hrs/wk)	89.0	95.4	159.0	183.5	204.1
	Domestic PA (MET-hrs/wk)	40.9	45.2	36.3	19.2	24.2
	Travel PA (MET-hrs/wk)	17.8	17.4	14.4	5.3	6.6
	Active Leisure PA (MET-hrs/wk)	11.9	14.8	6.5	4.8	4.4
	Total PA (MET-hrs/wk)	159.5	172.6	216.3	212.8	239.2
	Being sedentary (hrs/wk)	37.7	41.7	24.3	20.0	18.7
Annualized change between t1 and t2	Occupational PA (MET-hrs/wk)	−1.8	−1.5	−2.0	−9.0	−0.8
	Domestic PA (MET-hrs/wk)	−0.4	−0.3	−0.5	−1.2	−0.3
	Travel PA (MET-hrs/wk)	−0.1	0.4	−0.1	−0.3	−0.1
	Active Leisure PA (MET-hrs/wk)	0.2	0.2	0.1	0.1	0.1
	Total PA (MET-hrs/wk)	−2.2	−1.3	−2.6	−9.6	−1.1
	Being sedentary (hrs/wk)	0.3	0.4	0.1	0.3	0.0
Total % change between t1 and t2	Occupational PA (MET-hrs/wk)	−41.3%	−34.6%	−6.0%	−46.9%	−2.0%
	Domestic PA (MET-hrs/wk)	−26.4%	−20.5%	−6.8%	−52.1%	−4.9%
	Travel PA (MET-hrs/wk)	−17.8%	241.9%	−2.9%	−50.2%	−9.2%
	Active Leisure PA (MET-hrs/wk)	88.6%	71.3%	9.3%	120.3%	10.0%
	Total PA (MET-hrs/wk)	−32.2%	−20.2%	−5.6%	−44.9%	−2.3%
	Being sedentary (hrs/wk)	42.7%	46.6%	3.1%	32.3%	0.2%

		US[☼]	UK[☼]	Brazil [*€]	China [¥]	India [*‡]
Observed	**Years of data available (t1 to t2) Interval length**	**1965 to 2009 34 years**	**1961 to 2005 34 years**	**2002 to 2007 5 years**	**1991 to 2009 18 years**	**2000 to 2005 5 years**
Annualized % change between t1 and t2	Occupational PA (MET-hrs/wk)	−1.2%	−1.0%	−1.2%	−2.6%	−0.4%
	Domestic PA (MET-hrs/wk)	−0.8%	−0.6%	−1.4%	−2.9%	−1.0%
	Travel PA (MET-hrs/wk)	−0.5%	7.1%	−0.6%	−2.8%	−1.8%
	Active Leisure PA (MET-hrs/wk)	2.6%	2.1%	1.9%	6.7%	2.0%
	Total PA (MET-hrs/wk)	−0.9%	−0.6%	−1.1%	−2.5%	−0.5%
	Being sedentary (hrs/wk)	1.3%	1.4%	0.6%	1.8%	0.0%
Forecasted	**Forecasting Assumption (that provided a mid-range estimate)**	**Using 2003–2009 slope**	**Using 1961–2005 slope**	**Using 2002–2007 slope**	**Moving averages**	**Using 2000–2005 slope**
Forecasted for 2020[§]	Occupational PA (MET-hrs/wk)	74.3	73.1	132.5	172.9	191.6
	Domestic PA (MET-hrs/wk)	39.4	40.0	28.4	16.9	22.5
	Travel PA (MET-hrs/wk)	15.7	22.8	10.8	5.2	5.7
	Active Leisure PA (MET-hrs/wk)	12.7	17.5	7.9	5.1	4.9
	Total PA (MET-hrs/wk)	142.1	153.3	179.6	200.1	224.7
	Being sedentary (hrs/wk)	39.9	47.6	29.0	22.7	19.6
Total % change between t1 and 2020[§]	Occupational PA (MET-hrs/wk)	−51.0%	−49.9%	−21.7%	−50.0%	−8.0%
	Total PA (MET-hrs/wk)	−39.6%	−29.1%	−21.6%	−48.2%	−8.3%
	Being sedentary (hrs/wk)	51.0%	67.2%	22.9%	50.5%	5.0%
Forecasted for 2030[§]	Occupational PA (MET-hrs/wk)	61.0	58.2	112.1	163.4	183.2
	Domestic PA (MET-hrs/wk)	38.0	36.6	22.1	14.8	18.0
	Travel PA (MET-hrs/wk)	13.7	26.4	7.7	5.1	4.9
	Active Leisure PA (MET-hrs/wk)	13.5	19.3	9.0	5.3	5.5
	Total PA (MET-hrs/wk)	126.3	140.5	150.8	188.5	211.7
	Being sedentary (hrs/wk)	41.9	51.5	33.0	25.2	20.2
Total % change between t1 and 2030[§]	Occupational PA (MET-hrs/wk)	−59.8%	−60.1%	−33.8%	−52.8%	−12.0%
	Total PA (MET-hrs/wk)	−46.3%	−35.1%	−34.1%	−51.1%	−13.6%
	Being sedentary (hrs/wk)	58.6%	80.9%	39.8%	67.0%	8.5%

NIH-PA Author Manuscript
NIH-PA Author Manuscript

NIH-PA Author Manuscript
NIH-PA Author Manuscript

☼ Measures of energy expenditure for each domain at the population level in China, US and UK were derived from combining estimates on country-specific time-use in various domains over time, and looking up the Compendium of PA (1993 and 2000).

€ For Active Leisure in Brazil, we used the 2002 and 2008 Sao Paolo PA survey data annualized to derive the 2007 estimates for reporting. For domestic and travel PA and sedentary time, we used average activity measures found in the United States and China from periods of similar economic development to estimate these.

¥ Prior to 1997, the CHNS did not have travel or active leisure activities or sedentary leisure data, these values were "back" casted based on other years of data.

* There are no known measures of the energy expenditure for each domain at the population level in India or Brazil. Measures of energy expenditure for were based on past studies in India, the 2000 Compendium of PA based on occupation for Brazil, and the IPAQ guidelines for active leisure in Brazil.

‡ For domestic, travel, active leisure physical activity and sedentary time, we used China's measures from periods of similar economic development to estimate these.

§ Forecasts for 2020 and 2030 assume linear trends in changes in each domain of PA base on the assumption described. We tested multiple assumptions for each country but only report results from the assumption that provided the middle range of estimates for total PA. These are total % changes, not annualized % changes.