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Time use and physical activity: a shift away from movement across the globe

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Summary

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, but highlights the need for concerted efforts to monitor PA in a consistent manner globally, increase global PA and decrease sedentary behavior. 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 represent a major threat to global health.

Keywords: Physical activity, sedentary, time use.

Acronyms and abbreviations:
ATUS, American Time Use Survey; CHNS, China Health and Nutrition Survey; CVD, cardiovascular disease; GDP, gross domestic product; GPAQ, Global Physical Activity Questionnaire; ILO, International Labour Organization; IPAQ, International Physical Activity Questionnaire; MET, metabolic equivalents of task; MTUS, Multinational Time Use Study; PA, physical activity; PPP, purchasing power parity; SLOTH, sleep, leisure, occupation, transportation, home-based activities; STEPS, STEPwise approach to surveillance; UN, United Nations; WDI, World Development Indicators; WHO, World Health Organization.

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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 sleep,

leisure, occupation, transportation, home-based activities (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, the United Kingdom, 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.

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 favourable 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 behaviours (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 that 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 United States, 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 behaviour 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 United States, the United Kingdom, 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 United States, the United Kingdom 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.

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.

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 United States and the United Kingdom (31). The MTUS contains harmonized time use data for the United States and the United Kingdom from the last five decades.

American Time Use Survey

We also used the American Time Use Survey 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 nine 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 labour 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.

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) (32,39). 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 labour-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. As none of our data are 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 led an earlier initiative to measure daily physical activity levels as an important

dimension of research to create energy intake requirements (40,41). 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 labour-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 (42–46) 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.

Auxiliary data

World Bank World Development Indicators

The World Development Indicators is the primary World Bank database for development data from officially recognized international sources (47). 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.

Methods

Estimating average energy expenditure and sedentary behaviour across domains

China, United States and United Kingdom

For China, the United States and the United Kingdom, 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,

$$(Domain\ MET\ hours\ per\ week)_{a,i} = \sum_{s=1}^{S} Time_{s,i} \times MET_{s,i}, \text{ and}$$

$$(Total\ MET\ hours\ per\ week)_{i} = \sum_{a=1}^{A} Domain\ MET\ hours\ per\ week_{a,i},$$

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 behaviours (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 United States and China from periods of similar economic development (based on per capita GDP PPP) for each country (2002 Brazil to 1975 United States and 2006 China; 2007 Brazil to 1985 United States 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 (42,44,45), 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

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 5 years, a number of slopes were possible, including:

1. using the last two waves of data only (2008 and 2009 for the United States, 2000 and 2005 for the United Kingdom, 2006 and 2009 for China);
2. using the middle range of data only (2003 and 2009 for the United States, 1995 and 2005 for the United Kingdom, 2004 and 2009 for China);
3. using first and last years of data (1965 and 2009 for the United States, 1961 and 2005 for the United Kingdom, 1991 and 2009 for China);
4. using the annualized 3-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 per week, but because we have ignored sleep (which has stayed consistent over time at around 50 h week^{-1} or 47 MET h week^{-1}) (48) in our calculations, the lower threshold we are considering is around 104 MET h week^{-1}. This provided a range of feasible forecasted PA levels and sedentary time for the United States, the United Kingdom and China.

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 behaviours do not change. We report the estimates using different slopes in the appendix (Appendix Table A2). 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 United States, total PA from the four domains in 1965 was already somewhat low at 235 MET hours per 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 per week in 2009, and it is forecasted to be around 142 MET hours per week by 2020 and 126 MET hours per week by 2030 (see Fig. 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 behaviours will continue to increase to nearly 42 h week^{-1} by 2030.

United Kingdom

Total PA in the United Kingdom in 1961 was even lower than in the United States in 1965, 216 MET hours per week for adults, again with occupational PA constituting the majority. Total PA fell to 173 MET hours per week (20% decline) by 2005. Our forecasting shows that by 2020, total PA will sum to 153 MET hours per week and by 2030 to 140 MET hours per 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 h week^{-1} by 2030 (Fig. 2).

Brazil

Our estimates for Brazil in Fig. 3 show that total PA was 229 MET hours per week in 2002, declined to 214 in 2008, and will continue to decrease to 180 and 151 MET hours per 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 h week^{-1} to 29 and 33 h week^{-1} 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 per week for adults, with occupational PA constituting the majority. Total PA fell to 213 MET hours per week by 2009 largely due to declines in occupational, domestic and travel PA. Our forecast shows that total PA will be 200 MET hours per week by 2020 and 188 MET hours per week by 2030.

Table 1 Observed and forecasted changes in occupational, domestic, travel and active leisure activity, and time being sedentary

Observed	Years of data available (t1 to t2) Interval length	United States* 1965 to 2009 34 years	United Kingdom* 1961 to 2005 34 years	Brazil§† 2002 to 2007 5 years	China*‡ 1991 to 2009 18 years	India§¶ 2000 to 2005 5 years
Weekly at t1	Occupational PA (MET-hours per week)	151.7	145.8	169.3	345.8	208.2
	Domestic PA (MET-hours per week)	55.6	56.8	39.0	40.1	25.5
	Travel PA (MET-hours per week)	21.7	5.1	14.8	10.6	7.2
	Active Leisure PA (MET-hours per week)	6.3	8.6	5.9	2.2	4.0
	Total PA (MET-hours per week)	235.2	216.4	229.0	385.9	244.9
	Being sedentary (hours per week)	26.4	28.4	23.6	15.1	18.6
Weekly at t2	Occupational PA (MET-hours per week)	89.0	95.4	159.0	183.5	204.1
	Domestic PA (MET-hours per week)	40.9	45.2	36.3	19.2	24.2
	Travel PA (MET-hours per week)	17.8	17.4	14.4	5.3	6.6
	Active Leisure PA (MET-hours per week)	11.9	14.8	6.5	4.8	4.4
	Total PA (MET-hours per week)	159.5	172.6	216.3	212.8	239.2
	Being sedentary (hours per week)	37.7	41.7	24.3	20.0	18.7
Annualized change between t1 and t2	Occupational PA (MET- hours per week)	–1.8	–1.5	–2.0	–9.0	–0.8
	Domestic PA (MET-hours per week)	–0.4	–0.3	–0.5	–1.2	–0.3
	Travel PA (MET-hours per week)	–0.1	0.4	–0.1	–0.3	–0.1
	Active Leisure PA (MET-hours per week)	0.2	0.2	0.1	0.1	0.1
	Total PA (MET-hours per week)	–2.2	–1.3	–2.6	–9.6	–1.1
	Being sedentary (hours per week)	0.3	0.4	0.1	0.3	0.0
Total % change between t1 and t2	Occupational PA (MET-hours per week)	–41.3	–34.6	–6.0	–46.9	–2.0
	Domestic PA (MET-hours per week)	–26.4	–20.5	–6.8	–52.1	–4.9
	Travel PA (MET-hours per week)	–17.8	241.9	–2.9	–50.2	–9.2
	Active Leisure PA (MET-hours per week)	88.6	71.3	9.3	120.3	10.0
	Total PA (MET-hours per week)	–32.2	–20.2	–5.6	–44.9	–2.3
	Being sedentary (hours per week)	42.7	46.6	3.1	32.3	0.2
Annualized % change between t1 and t2	Occupational PA (MET-hours per week)	–1.2	–1.0	–1.2	–2.6	–0.4
	Domestic PA (MET-hours per week)	–0.8	–0.6	–1.4	–2.9	–1.0
	Travel PA (MET-hours per week)	–0.5	7.1	–0.6	–2.8	–1.8
	Active Leisure PA (MET-hours per week)	2.6	2.1	1.9	6.7	2.0
	Total PA (MET-hours per week)	–0.9	–0.6	–1.1	–2.5	–0.5
	Being sedentary (hours per week)	1.3	1.4	0.6	1.8	0.0

Table 1 *Continued*

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-hours per week)	74.3	73.1	132.5	172.9	191.6
	Domestic PA (MET-hours per week)	39.4	40.0	28.4	16.9	22.5
	Travel PA (MET-hours per week)	15.7	22.8	10.8	5.2	5.7
	Active Leisure PA (MET-hours per week)	12.7	17.5	7.9	5.1	4.9
	Total PA (MET-hours per week)	142.1	153.3	179.6	200.1	224.7
	Being sedentary (hours per week)	39.9	47.6	29.0	22.7	19.6
Total % change between t1 and 2020**	Occupational PA (MET-hours per week)	–51.0	–49.9	–21.7	–50.0	–8.0
	Total PA (MET-hours per week)	–39.6	–29.1	–21.6	–48.2	–8.3
	Being sedentary (hours per week)	51.0	67.2	22.9	50.5	5.0
Forecasted for 2030**	Occupational PA (MET-hours per week)	61.0	58.2	112.1	163.4	183.2
	Domestic PA (MET-hours per week)	38.0	36.6	22.1	14.8	18.0
	Travel PA (MET-hours per week)	13.7	26.4	7.7	5.1	4.9
	Active Leisure PA (MET-hours per week)	13.5	19.3	9.0	5.3	5.5
	Total PA (MET-hours per week)	126.3	140.5	150.8	188.5	211.7
	Being sedentary (hours per week)	41.9	51.5	33.0	25.2	20.2
Total % change between t1 and 2030§	Occupational PA (MET-hours per week)	–59.8	–60.1	–33.8	–52.8	–12.0
	Total PA (MET-hours per week)	–46.3	–35.1	–34.1	–51.1	–13.6
	Being sedentary (hours per week)	58.6	80.9	39.8	67.0	8.5

*Measures of energy expenditure for each domain at the population level in China, United States and United Kingdom 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 India 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.

CHNS, China Health and Nutrition Survey; MET, metabolic equivalents of task; PA, physical activity.

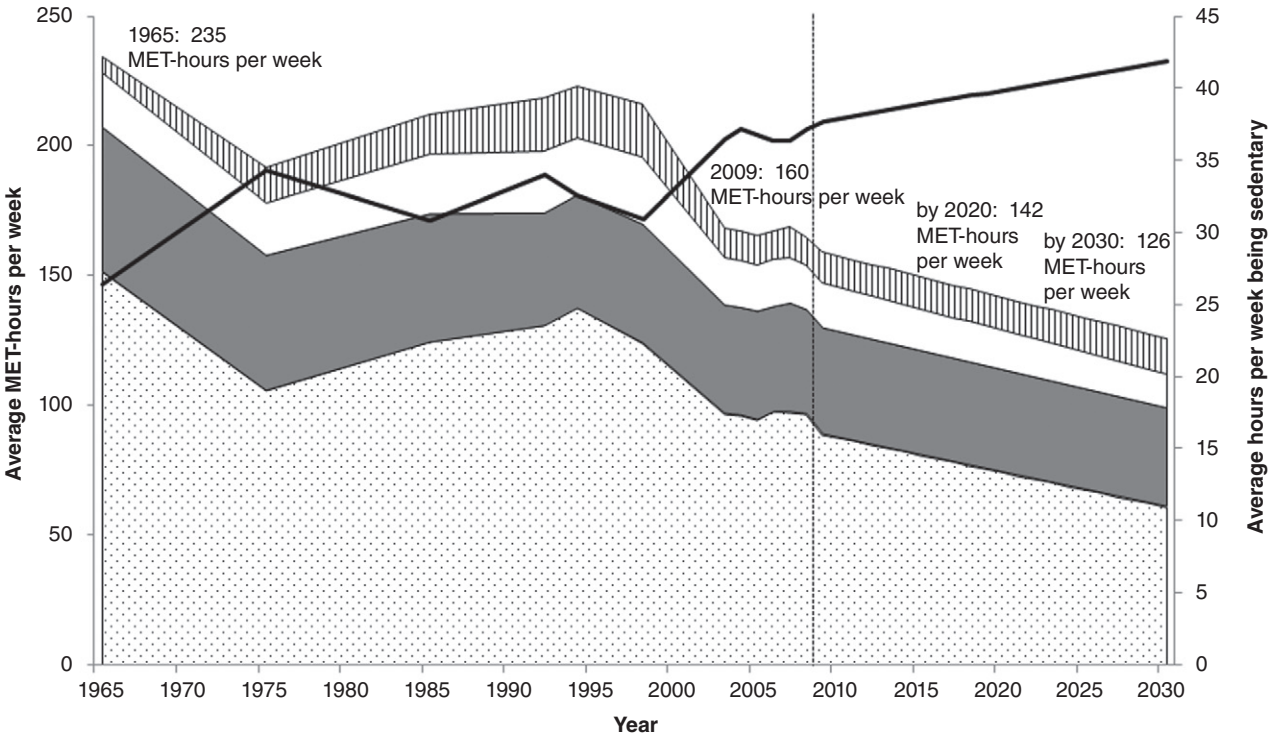

Figure 1 US adults metabolic equivalents of task (MET)-hours per week of all physical activity, and hours per week of time in sedentary behaviour: measured for 1965–2009, forecasted for 2010–2030.
Source: Multinational Time Use Studies (MTUS) v.5.52 (1965, 1975, 1998) and v.5.8 (1985, 1992, 1995), and 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.
active leisure PA, travel PA, domestic PA, occupational PA, sedentary time.

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 behaviours will increase from about 20 h week^{-1} in 2009 to 23 h week^{-1} in 2020 and 25 h week^{-1} 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 h week^{-1} in 2000 to 20 h week^{-1} by 2030.

Conclusions

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 labour-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 per 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 United States and the United Kingdom are consistent with earlier work by others who

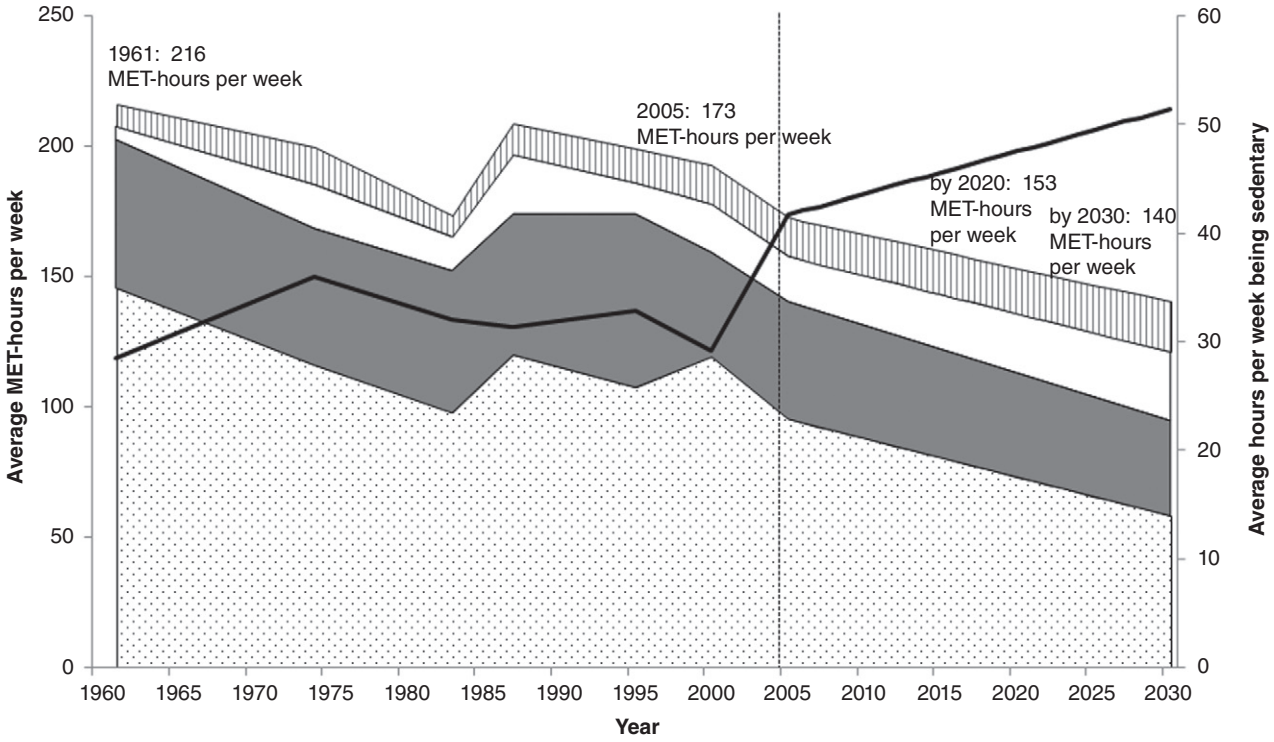

Figure 2 UK adults metabolic equivalents of task (MET)-hours per week of all physical activity, and hours per week of time in sedentary behaviour: measured for 1961–2005, forecasted for 2006–2030.
Source: Multinational Time Use Studies (MTUS) v.5.52 (1961, 1983, 1987) and v.5.8 (1974, 1995, 2000, 2005); 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.
active leisure PA, travel PA, domestic PA, occupational PA, sedentary time.

looked at specific domains (34,48–50). In the United States and the United Kingdom, second car ownership has increased, the distance walked per year has declined and the vehicle miles travelled have increased (34,50–53). The trend is less severe in the United Kingdom, where active transport is promoted and urban design is more conducive to walking and bicycling (45). The increased sedentary time in the United States, the United Kingdom, 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 (54).

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 (42–45). The Indian National Rural Employment Guarantee Act (55), which provides partial employment to unemployed adults, mainly involves manual labour (laying roads, digging wells, etc.) and will likely have an impact on the PA profile in rural areas.

Our time use data for the United States, the United Kingdom and China (see Appendix Figs A1–A3) 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 (56). For US women, time spent on domestic activities fell by one third from 1965 and to 1995, from about 40 to 27 h week^{-1} (57). 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 2 h week^{-1} to half an hour per week (58,59).

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 United States, the United

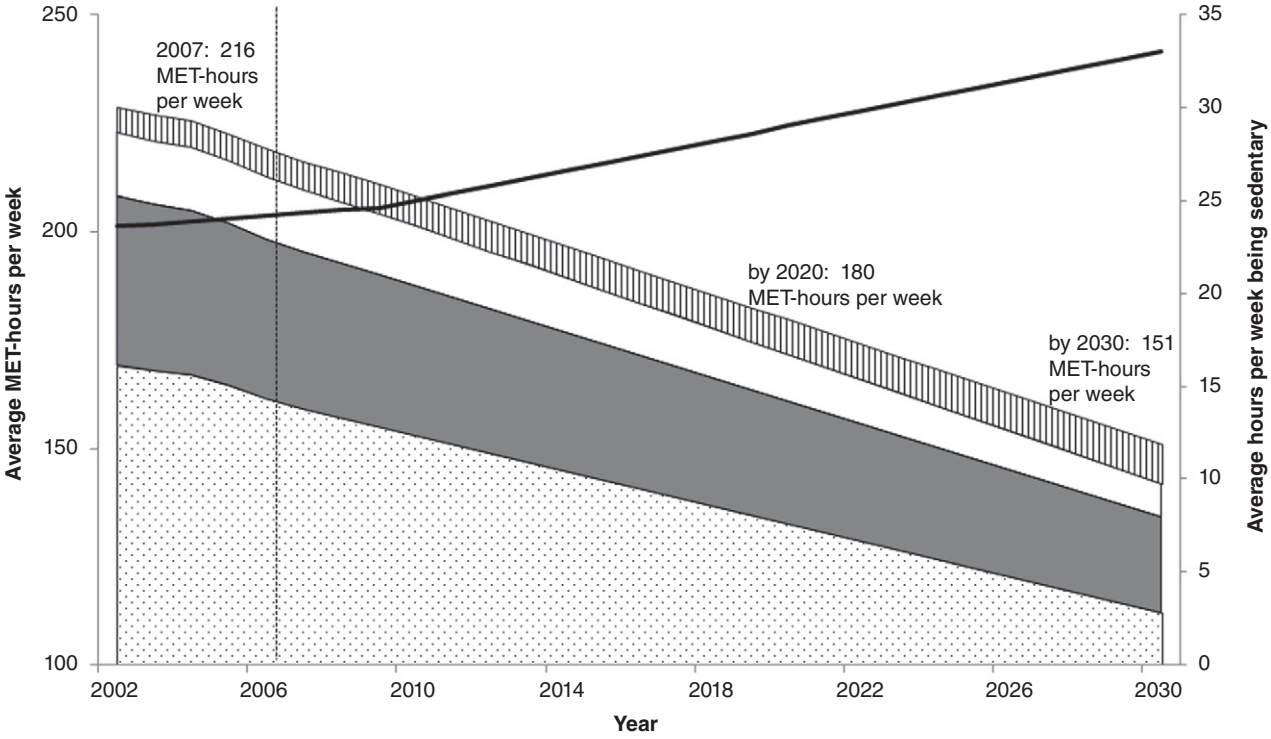

Figure 3 Brazilian adults metabolic equivalents of task (MET)-hours per week of all physical activity, and hours per week of time in sedentary behaviour: measured for 2002–2007, forecasted for 2009–2030.
Source: Occupational physical activity based on 2002–2007 UN-ILO statistics applying MET-intensity values from the Compendium of Physical Activity. 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 per hour; moderate only = 4 METs per hour; vigorous only = 8 METs per hour. All other energy expenditure and sedentary time values are estimated from applying the average activity measures found in the United States and China from periods of similar economic development (based on per capita gross domestic product purchasing power parity) for each of these countries (2002 Brazil to 1975 United States and 2006 China; 2008 Brazil to 1985 United States and 2009 China). Forecasting for 2009–2030 based on 2002–2007 slopes.
▥ active leisure PA, ▭ travel PA, ▬ domestic PA, ⁘ occupational PA, ━ sedentary time.

Kingdom 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 United States. 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 PA 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 (40,41,46,60). 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 g for food as METs provide measures of energy expenditures per minute or hour. In order to improve our measurement of energy expenditure, long-term investments into creating a centralized, sustainable and publically accessible country- or context-specific database is necessary.

This paper does not discuss the major cultural, social, physical and economic barriers that need to be addressed if behaviour change is to be promoted in favour of increased PA or to discourage sedentary behaviour (61). Similarly, we have not described or discussed the social gradients that exist among different income or education groups within a

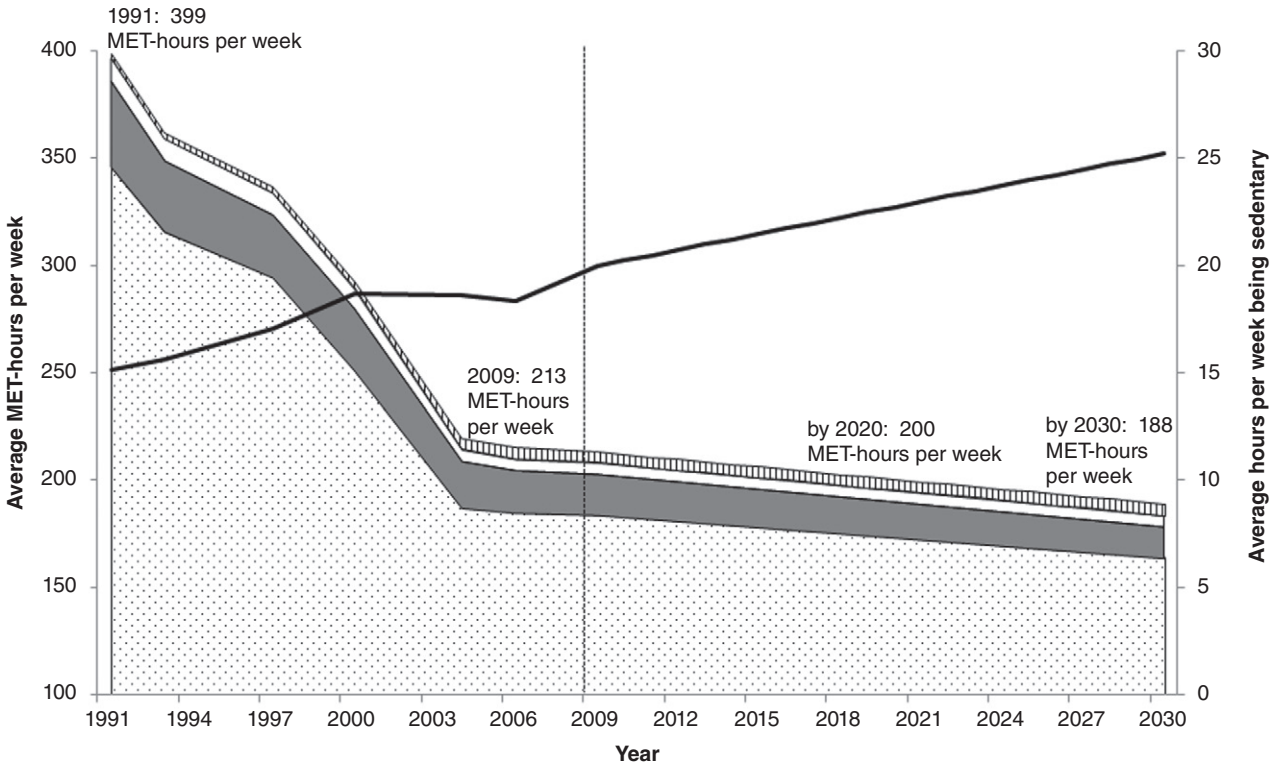

Figure 4 Chinese adults metabolic equivalents of task (MET)-hours per week of all physical activity, and hours per week of time in sedentary behaviour: measured for 1991–2009, forecasted for 2010–2030.
Source: China Health and Nutrition Surveys 1991, 1993, 1997, 2000, 2004, 2006, 2009; Applying Compendium 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.
active leisure PA, travel PA, domestic PA, occupational PA, sedentary time.

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 modelled 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.

Implications

It is clear that there exist major gaps in measuring PA, sedentary behaviour 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 (45,62,63), but it has never been pulled together in a complete reference volume. It would be enormously valuable for an international agency or team of researchers to organize, create and update 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 (United Kingdom) and the National Health and Nutrition Examination Survey (United States) 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 (64).

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 United Kingdom, but this rate of change needs to occur faster than currently projected towards the examples of other European countries, such as the Netherlands and Denmark (65). In contrast, in the United States 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,

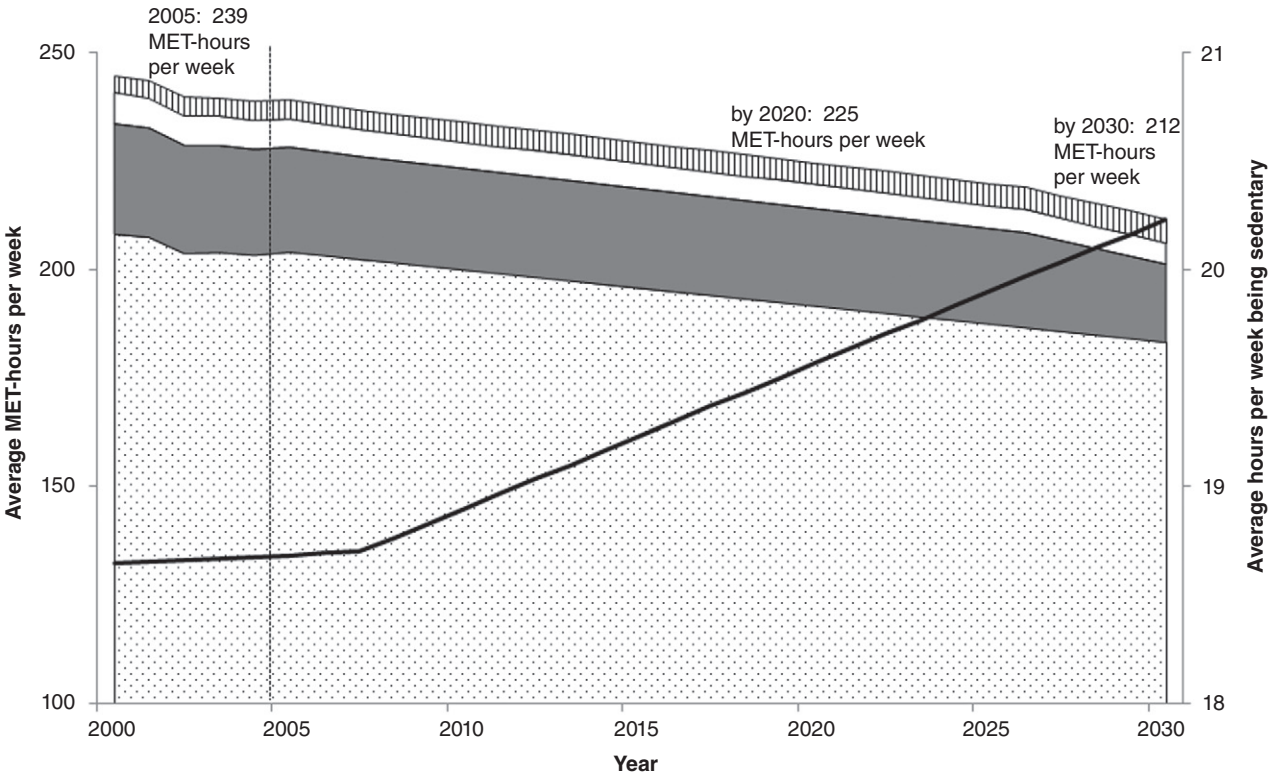

Figure 5 Indian adults metabolic equivalents of task (MET)-hours per week of all physical activity, and hours per week of time in sedentary behaviour: measured for 2000–2005, forecasted for 2006–2030.
Source: Occupational physical activity based on 2000–2005 UN-ILO statistics applying the following MET-intensity 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 gross domestic product purchasing power parity) 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.

supportive land use planning and restrictions on car use (53,66,67). 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 (68), 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 towards reduced travel PA along with growing vehicle ownership (69). 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 United States, the United Kingdom, Australia and Brazil, but is minimal for many other countries. The Agita Mundo initiative is exemplary for addressing movement in leisure and other modes (70–73). However, to date the slight upward trends in active leisure in the United Kingdom, the United States 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 (61). 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 behaviour will have significant implications for the health outcomes, healthcare 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

behaviour. 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 (18,74) will be effective and that our estimates will never become reality. This multi-country study represents in many ways a global call for action to reduce sedentary behavior and increase PA across multiple domains of daily activity.

Conflict of Interest Statement

Nike, Inc., commissioned this work for independent study. 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.

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Appendix: data sources available for estimating physical activity and inactivity over time

We document the various sources of data that could be used for estimating physical activity and inactivity over time across the five countries of interest (United States, United Kingdom, Brazil, China and India). Many of these data sources are publically available. However, some of the public data are at the aggregate level or are not detailed enough for use in our study (denoted with ¥). In addition, many of these require special permission for access and we were unable to obtain them (denoted with *).

United States

The United States has a disparate number of data sources, each contain information that can be useful for studying factors associated with different domains of activity.

1. Occupational activity: The Current Population Survey has agricultural employment data going back to 1940; the Current Employment Statistics has non-agricultural industry employment from 1960 onwards; the Occupational Employment Statistics (only comparable from 1997) provides estimates on the physical requirements for occupations; and the Integrated Public Use Microdata Series contains all Census occupation data according to the 1950-based occupation classification.

2. Home/Domestic activity: These can only be inferred from the American Heritage Time Use Study (AHTUS) 1965–1966, 1975–1976, 1985, 1992–1994, 1994–1995, 1998–1999, 2000–2001, and the American Time Use Survey (ATUS) since 2003 (more details below in Section IIC).

3. Travel activity: In the United States, the Federal Highway Administration (FHWA) conducts the National Household Travel Survey since 2001, and the former Nationwide Personal Transportation Surveys of 1969, 1977, 1983, 1990 and 1995, which are the primary source of data on modes and time spent travelling on a usual basis. The FHWA also collects annual data on vehicles miles travelled. It is also possible to infer travel activity from the AHTUS and ATUS.

4. Active leisure activity: Estimates of active leisure activity among adults may be derived from the National Health Interview Survey (NHIS) from 1975 to 2007, the National Health and Nutrition Examination Survey (NHANES) from 1999 to 2008 and the Behavioral Risk Factor Surveillance System (BRFSS) from 1990 to 2010. BRFSS, NHANES and the earlier years of the NHIS use questions that only ask about whether respondents participated in sports or exercise and how frequently in the past week or month, and do not ask about specific types of active leisure and therefore while useful for determining if recommendations are met, they are not useful for estimating energy expenditure in active leisure. Since 1995, the NHIS does ask more detail about the various types of active leisure, frequency and time spent in each type of active leisure, which provide more detail and variability in energy expenditure across individuals. It is also possible to infer active leisure activity from the AHTUS and ATUS.

5. Sedentary Leisure behaviour: The NHIS, NHANES and BRFSS also do ask questions about being sedentary/inactive, but these are limited to prevalence measures rather than on the amount of sedentariness. In addition, the commercial Nielsen Media Research data can provide more detailed information of media time (television, radio, computers, movies, etc.). Again, it is possible to infer sedentary leisure behaviours from the AHTUS and ATUS.

US data compiled and harmonized by MTUS

The Multinational Time Use Study (MTUS) contains harmonized time-use data for the United States from the last five decades. These include data from the 1965–1966 Multinational Comparative Time-Budget Research Project, the 1975–1976 and 1985 American's Use of Time Project, the 1992–1994 National Human Activity Pattern Survey, the 1994–1995 National Time-Diary Study, the 1998–1999 Family Interaction, Social Capital, and Trends in Time Use Study, the 1999–2001 National Survey of Parents, and the 2003 ATUS. Future versions of the MTUS will include additional ATUS for the United States.

The ATUS

The US Bureau of Labor Statistics collects the ATUS since 2003. The ATUS provide detailed data on time-use patterns for an extensive array of activities (including those that coincide with other activities) from over 98,000 interviews. At the time of this study, the MTUS did not yet include the 2004–2009 ATUS. Therefore, we attempted to harmonize the 2003–2009 ATUS with the rest of the US time-use data in the MTUS on our own based on MTUS documentation.[1] As the MTUS-US also contained the 2003 ATUS data, we compared the measurements for time spent in the five domains of activities in the two versions (ATUS multi-year 2003–2009 and MTUS) and their correlation was 0.73, indicating that our efforts to harmonize the ATUS data with the MTUS-US data were reasonable. In order to maintain consistency across the years of ATUS available, we dropped the 2003 data from the MTUS and used the ATUS for 2003–2009.

United Kingdom or England

Measures of physical activity are primarily epidemiological estimates on proportion of the population meeting national recommendations and the International Physical Activity Questionnaire (IPAQ).[2,3] A report that provides additional detail concerning the strengths and limitations of the physical activity surveillance measures in England[3] lists the following national surveys that contain the main measures of adult participation in physical activity:

1. Health Survey for England (HSE): The HSE reports on adults' physical activity in the 4 weeks prior to interview by examining overall participation in sport and exercise activities that lasted at least 10, 15 or 30 min (depending on the survey year) and by describing frequency and indicators of intensity of participation, intensity and type of activity. Physical activity is not measured every year, but is included as a module in 1991/1992, 1993, 1994, 1997, 1998, 1999, 2003 and 2004[4], and most recently, in 2008. There are plans to incorporate the HSE into a broader Health and Social Care Survey from 2011.

2. Active People Survey: Some aspects of total physical activity are measured in Sport England's Active People survey. This survey focuses on activities that are done primarily for sport and active recreation and lasts at least 30 min per occasion. The survey began in October 2005, and is planned to run continuously until 2010.

3. National Travel Survey (NTS): The NTS measures all aspects of personal travel, including walking and cycling as transport based on week-long travel diaries. The survey has been running on an ad hoc basis since 1965 and continuously since 1988.

4. General Household Survey (GHS): The GHS is a multi-purpose continuous survey carried out by the Social Survey Division of the Office for National Statistics which collects information on a range of topics from people living in private households in Great Britain. The survey started in 1971 and has been carried out continuously since then, except for breaks in 1997/1998 (when the survey was reviewed) and 1999/2000 when the survey was re-developed. This survey includes measures on sport and recreation including walking.

5. National Diet and Nutrition Survey (NDNS): A new rolling NDNS commenced data collection in April 2008. This survey was conducted initially to assess nutritional intake, but since year 2 of the NDNS (April 2009), the Recent Physical Activity Questionnaire is being used to categorize participants' physical activity levels.[5]

As shown, physical activity measures in the United Kingdom is limited to the domains of active leisure and travel, and typically do not include activity level at work or from home production. Therefore, an alternative is to look at surveys that include information on people's time-use, such as what is compiled in the Multinational Time-Use Survey for the United Kingdom.

UK data compiled and harmonized by MTUS

The MTUS contains harmonized time-use data for the United Kingdom from the last five decades. These include data from the 1961 People's Activities, the 1974–1975 People's Activities and Use of Time, the 1983–1984 ESRC Time Budget Survey, the 1987 Social Change and Economic Life Initiative Surveys, the 1995 OPCS Omnibus Survey Time Use module, the 2000–2001 National Survey of Time Use and the 2005 Omnibus survey.

Brazil

Like the United Kingdom, measures of physical activity in Brazil are primarily epidemiological estimates on proportion of the population (national or local/regional) meeting national or international recommendations (150 min per week of moderate to vigorous activity) and the IPAQ-short. A 2009 systematic review article by Dumith[6] provides an overview of the various types of physical activity research conducted in Brazil. Only three studies include data collected from cities from more than one State or region, and only two include repeated cross-sectional surveys over time:

1. 1996–1997 Brazilian Living Standards Measurement Survey (LSMS): The Brazil LSMS included 11,033 persons ≥20 years selected from the two most populous Brazilian regions (Northeast and Southeast), where in total 70% of all Brazilians live. The selected persons responded to a series of questions concerning their leisure-time physical activities.[7]

2. 2005 cross-sectional study using the IPAQ was conducted among a sample of adults from 41 cities* in the states of Rio Grande do Sul and Santa Catarina in the South, Alagoas, Pernambuco, Paraiba, Rio Grande do Norte and Piaui in northeastern Brazil.[8]

3. Surveillance System of Risk and Protective Factors for Chronic Non-Communicable Diseases through Telephone Interviews (VIGITEL)¥: This nationwide survey has been conducted annually since 2006 in all the State capitals plus the Federal District. It collects information on the frequency and duration of engaging in leisure time physical exercise and of being inactive (e.g. watching television). However, we were only able to obtain data on the proportion of adults who engage in active leisure PA and the proportion of adults who watch television for three or more hours per day on average.

4. 2002, 2003, 2006, 2008 Sao Paulo Physical Activity study: This include cross-sectional surveys in 2002, 2003, 2006 and 2008 in the state of Sao Paulo, Brazil, using comparable sampling approaches and similar sample sizes. In all surveys, physical activity was measured using the short version of the IPAQ.[9]

5. 2002 Pelotas Physical Activity study*: This was a cross-sectional survey conducted in the southern city of Pelotas in 2002 using the IPAQ-short to measure the prevalence of inactivity in this population.[10]

China

China participated in the WHO World Health Survey 2002–2003¥, which used the IPAQ-short to estimate proportion of population who were inactive, but no other data on PA is available.

In 1992 and 2002, the Chinese Center for Disease Control and Prevention conducted the National Nutrition and Health Surveys (CNNHS)*, which were nationally representative and included questions about PA.[11] Finally, the longitudinal China Health and Nutrition Surveys (CHNS) conducted since 1989 is publicly available and provide details on time spent in various activities along with questions about the strenuousness of occupations.

India

Measures of physical activity in India are primarily epidemiological estimates on physical activity prevalence. As part of the WHO World Health Survey, the IPAQ-short was used to collect data on physical activity prevalence in India in 2003¥. In addition, India conducted the WHO STEP surveys in 2004 and 2007 (using Global Physical Activity Questionnaire [GPAQ])*, and also conducted a 2008 SAGE study using the GPAQ*.

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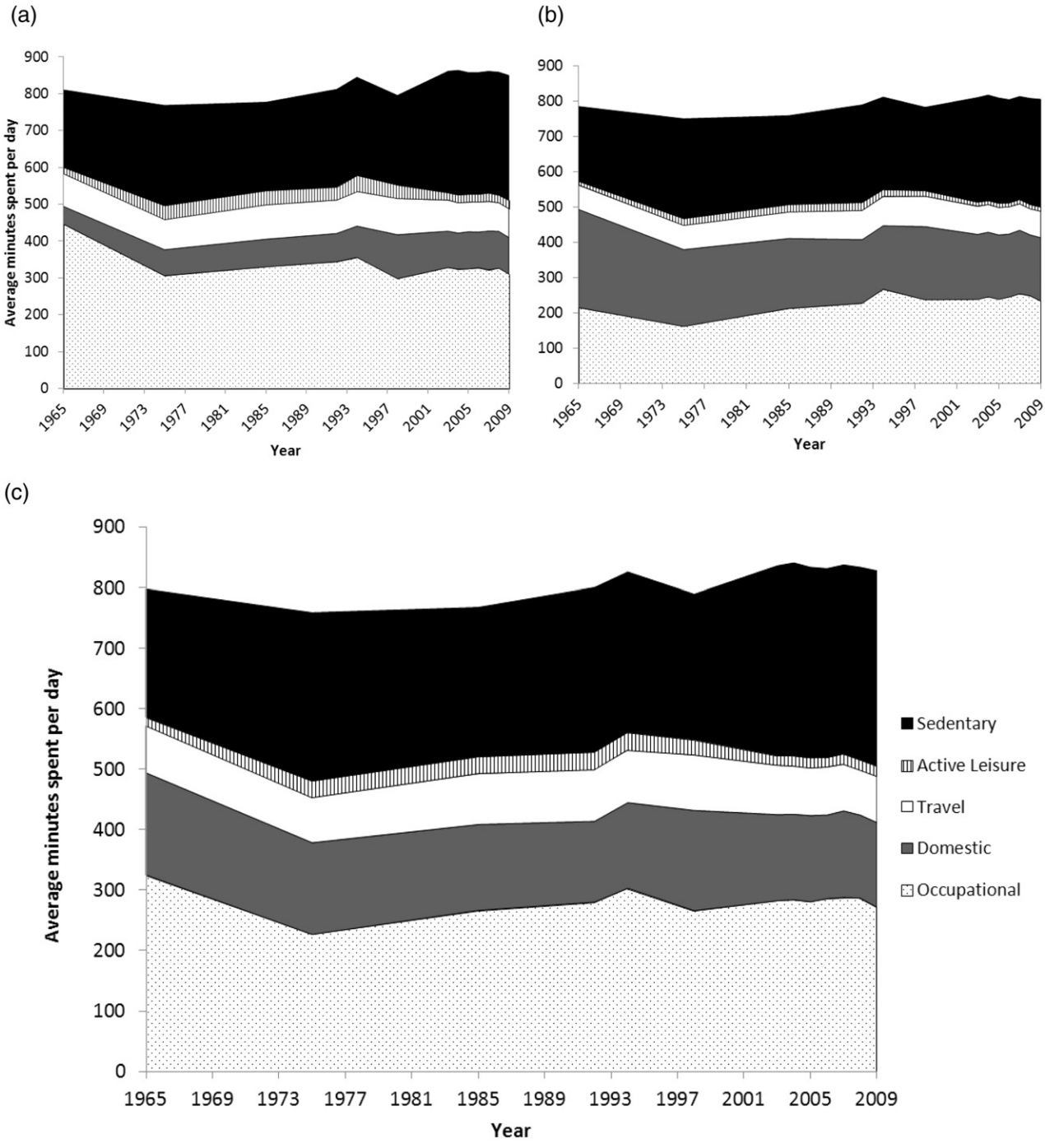

Figure A1 Time use among adults in the United States, 1965–2009. (a) Adult men in the United States, 1965–2009; (b) adult women in the United States, 1965–2009; (c) time use among adults (18–64 years) in the United States, 1965–2009.
Source: Multinational Time Use Studies v.5.52 (1965, 1975, 1998) and v.5.8 (1985, 1992, 1995), and American Time Use Survey 2003–2009.

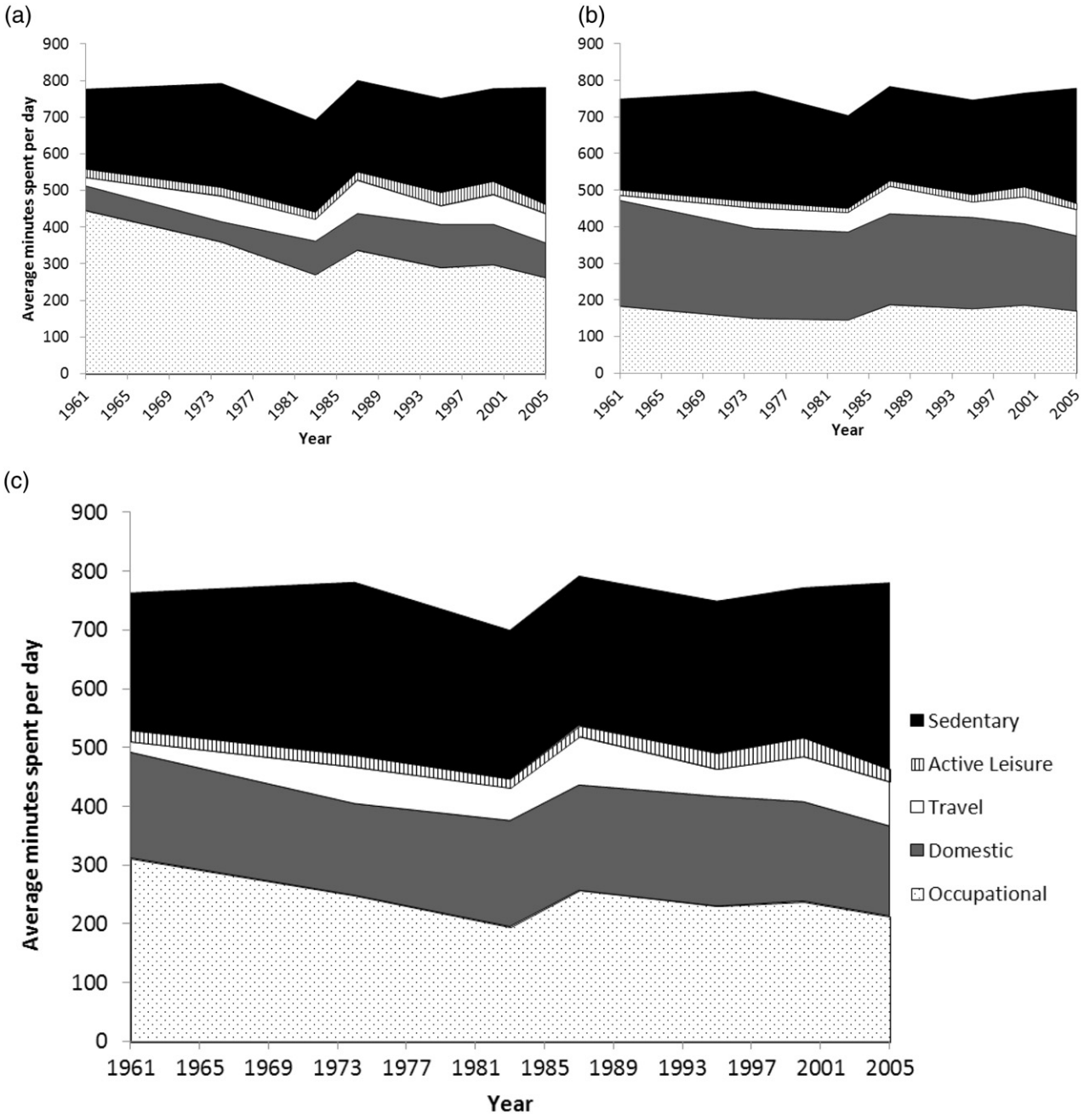

Figure A2 Time use among adults in the United Kingdom, 1961–2005. (a) Adult men (18–64 years) in the United Kingdom, 1961–2005; (b) adult women (18–64 years) in the United Kingdom, 1961–2005; (c) time use by adults (18–64 years) in the United Kingdom, 1961–2005.
Source: Multinational Time Use Studies v.5.52 (1961, 1983, 1987) and v.5.8 (1974, 1995, 2000, 2005).

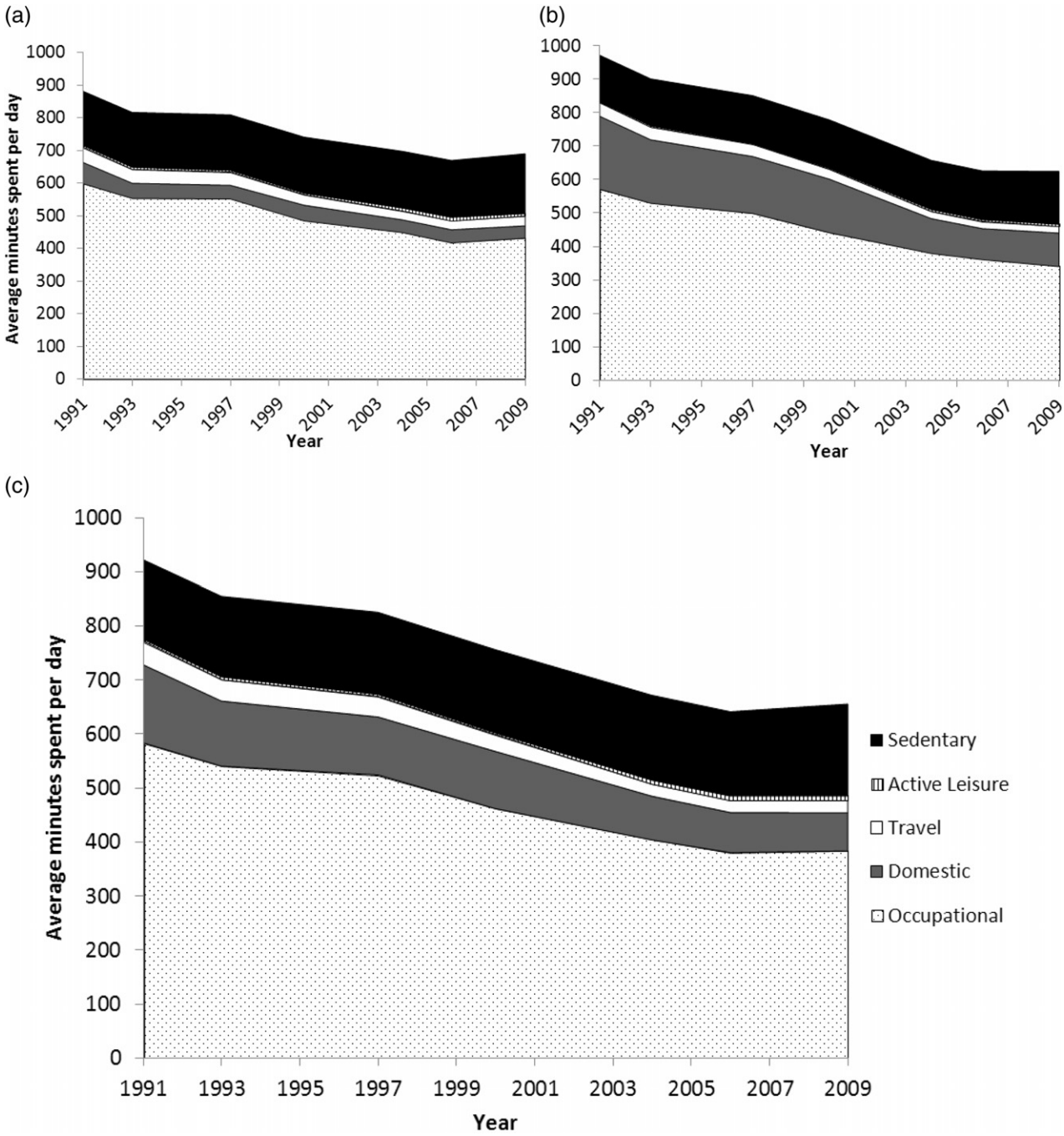

Figure A3 Time use among adults in the China, 1991–2009. (a) Adult men in China, 1991–2009; (b) adult women in China, 1991–2009; (c) time use among adults (18–64 years) in China, 1991–2009.
Source: China Health and Nutrition Surveys 1991, 1993, 1997, 2000, 2004, 2006, 2009.

Table A1 Cross-country databases and variables used

	United States	United Kingdom	Brazil	China	India
Gender	MTUS v.5.52 (1965, 1975, 1998)	MTUS v.5.52 (1961, 1983, 1987)	UN World Population Prospects (sex-ratio)	CHNS 1991–2009	UN World Population Prospects (sex ratio)
Time spent (hours per week)	MTUS v.5.8 (1985, 1992, 1995)	MTUS v.5.8 (1974, 1995, 2000, 2005)			
At work (occupation)	ATUS 2003–2009		UN-ILO average hours spent working in different economic activities by gender and proportion of population in different economic activities among Brazilians in 2002 and 2008		UN-ILO average hours spent working in different economic activities by gender and proportion of population in different economic activities among Indians in 2000 and 2005
In domestic activities Travelling			Derived from applying 1975 United States and 2006 China for 2002 Brazil; 1985 United States and 2009 China to 2007 Brazil		Derived from applying 1995 China for 2000 India; 2000 China to 2005 India
Exercising (active leisure)			Sao Paolo Physical Activity Survey 2008		
Being sedentary			Derived from applying 1975 US and 2006 China for 2002 Brazil; 1985 United States and 2009 China to 2007 Brazil		
Energy intensity	Compendium of Physical Activities	Compendium of Physical Activities	Compendium of Physical Activities for Occupational PA; IPAQ-short guidelines: walking = 3.3 MET per hour; moderate only = 4 METs per hour; vigorous only = 8 METs per hour	Compendium of Physical Activities	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.
Per capita gross domestic product adjusted for purchasing power parity			World Bank Indicators		

Table A2 Observed and forecasted ranges of estimated changes in occupational, domestic, travel and active leisure activity, and time being sedentary

	Slope used assuming linearity	United States (t1 = 1965)			United Kingdom (t1 = 1961)			Brazil* (t1 = 2002)	China (t1 = 1991)			India* (t1 = 2000)
		Moving averages	Using 2003–2009 slope	Using last two waves only (2008–2009)	Using 1995–2005 slope	Using 1961–2005 slope	Moving averages	Using 2002–2007 slope	Using 2004–2009 slope	Moving averages	Using last two waves only (2006–2009)	Using 2000–2005 slope
Forecasted for 2020†	Occupational PA (MET-hours per week)	73.0	74.3	86.4	77.0	73.1	89.4	132.5	176.3	172.9	179.9	191.6
	Domestic PA (MET-hours per week)	38.6	39.4	41.1	31.8	40.0	37.6	28.4	13.2	16.9	16.4	22.5
	Travel PA (MET-hours per week)	16.3	15.7	17.9	25.7	22.8	24.3	10.8	5.1	5.2	5.8	5.7
	Active Leisure PA (MET-hours per week)	12.2	12.7	12.2	17.0	17.5	17.9	7.9	4.2	5.1	2.9	4.9
	Total PA (MET-hours per week)	140.0	142.1	157.6	151.5	153.3	169.2	179.6	198.8	200.1	205.0	224.7
	Being sedentary (hours per week)	40.0	39.9	37.9	55.0	47.6	46.7	29.0	23.0	22.7	25.9	19.6
Annualized change between t1 and 2020	Occupational PA (MET-hours per week)	−1.4	−1.4	−1.2	−1.4	−1.5	−1.2	−2.0	−5.8	−6.0	−5.7	−0.9
	Domestic PA (MET-hours per week)	−0.3	−0.3	−0.3	−0.5	−0.3	−0.4	−0.6	−0.9	−0.8	−0.8	−0.2
	Travel PA (MET-hours per week)	−0.1	−0.1	−0.1	0.4	0.4	0.4	−0.2	−0.2	−0.2	−0.2	−0.1
	Active leisure PA (MET-hours per week)	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.1
	Total PA (MET-hours per week)	−1.7	−1.7	−1.4	−1.3	−1.3	−1.0	−2.7	−6.5	−6.4	−6.2	−1.1
	Being sedentary (hours per week)	0.2	0.2	0.2	0.5	0.4	0.4	0.3	0.3	0.3	0.4	0.1
Annualized % change between t1 and 2020	Occupational PA (MET-hours per week)	−0.9	−0.9	−0.8	−1.0	−1.0	−0.8	−1.2	−1.7	−1.7	−1.7	−0.3
	Domestic PA (MET-hours per week)	−0.6	−0.5	−0.5	−0.9	−0.6	−0.7	−1.5	−2.3	−2.0	−2.0	−0.4
	Travel PA (MET-hours per week)	−0.5	−0.5	−0.3	8.3	7.1	7.7	−1.5	−1.8	−1.8	−1.5	−0.7
	Active leisure PA (MET-hours per week)	1.7	1.9	1.7	2.0	2.1	2.2	1.9	3.1	4.5	1.2	0.8
	Total PA (MET-hours per week)	−0.7	−0.7	−0.6	−0.6	−0.6	−0.4	−1.2	−1.7	−1.7	−1.6	−0.3
	Being sedentary (hours per week)	0.9	0.9	0.8	1.9	1.4	1.3	1.3	1.8	1.7	2.5	0.2
Forecasted for 2030†	Occupational PA (MET-hours per week)	58.4	61.0	84.1	64.8	58.2	85.4	112.1	169.8	163.4	176.6	183.2
	Domestic PA (MET-hours per week)	36.4	38.0	41.4	23.0	36.6	32.6	22.1	7.8	14.8	13.8	18.0
	Travel PA (MET-hours per week)	14.9	13.7	18.0	31.3	26.4	28.9	7.7	4.9	5.1	6.4	4.9
	Active leisure PA (MET-hours per week)	12.4	13.5	12.4	18.4	19.3	20.0	9.0	3.6	5.3	1.2	5.5
	Total PA (MET-hours per week)	122.2	126.3	155.9	137.5	140.5	166.8	150.8	186.1	188.5	198.0	211.7
	Being sedentary (hours per week)	42.2	41.9	38.0	63.8	51.5	50.0	33.0	25.8	25.2	31.2	20.2
Annualized change between t1 and 2030	Occupational PA (MET-hours per week)	−1.4	−1.4	−1.0	−1.4	−1.5	−1.0	−2.0	−4.5	−4.7	−4.3	−0.9
	Domestic PA (MET-hours per week)	−0.3	−0.3	−0.2	−0.6	−0.3	−0.4	−0.6	−0.8	−0.6	−0.7	−0.3
	Travel PA (MET-hours per week)	−0.1	−0.1	−0.1	0.4	0.4	0.4	−0.3	−0.1	−0.1	−0.1	−0.1
	Active leisure PA (MET-hours per week)	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.0	0.1	0.0	0.1
	Total PA (MET-hours per week)	−1.7	−1.7	−1.2	−1.3	−1.3	−0.8	−2.8	−5.1	−5.1	−4.8	−1.2
	Being sedentary (hours per week)	0.2	0.2	0.2	0.6	0.4	0.4	0.3	0.3	0.3	0.4	0.1
Annualized % change between t1 and 2030	Occupational PA (MET-hours per week)	−0.9	−0.9	−0.7	−0.9	−1.0	−0.7	−1.2	−1.3	−1.4	−1.3	−0.4
	Domestic PA (MET-hours per week)	−0.5	−0.5	−0.4	−1.0	−0.6	−0.7	−1.5	−2.1	−1.6	−1.7	−1.0
	Travel PA (MET-hours per week)	−0.5	−0.6	−0.3	8.7	7.1	7.9	−1.7	−1.4	−1.3	−1.0	−1.2
	Active Leisure PA (MET-hours per week)	1.5	1.8	1.5	1.9	2.1	2.2	1.9	1.6	3.6	−1.1	1.4
	Total PA (MET-hours per week)	−0.7	−0.7	−0.5	−0.6	−0.6	−0.4	−1.2	−1.3	−1.3	−1.2	−0.5
	Being sedentary (hours per week)	0.9	0.9	0.7	2.1	1.4	1.3	1.4	1.8	1.7	2.7	0.3

*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.

†Forecasts for 2020 and 2030 assume linear trends in changes in each domain of PA base on the assumption described. These are total % changes, not annualized % changes.