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Maternal Inactivity: 45-Year Trends in Mothers' Use of Time

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Abstract

Objective: To examine 45-year trends in time use and physical activity energy expenditure (PAEE) in a nationally representative sample of US mothers.

Participants and Methods: We quantified time allocation to physical activity (PA), sedentary behaviors (SED), and PAEE from 1965 to 2010 in mothers with older children (MOC) (>5 to ≤18 years) and mothers with younger children (MYC) (≤5 years). Physical activity was the sum of time allocated to housework, child care, laundry, food preparation, postmeal cleanup, and exercise. Sedentary behavior was the sum of time spent in a vehicle and using screen-based media. Physical activity energy expenditure was calculated using body weights from national surveys and metabolic equivalents.

Results: From 1965 to 2010, the time allocated to PA decreased by 11.1 h/wk (from 32.0 to 20.9 h/wk) in MOC and by 13.9 h/wk (from 43.6 to 29.7 h/wk) in MYC. The time spent in SED increased by 7.0 h/wk in MOC (from 17.7 to 24.7 h/wk) and increased by 5.7 h/wk in MYC (from 17.0 to 22.7 h/wk). Physical activity energy expenditure decreased by 1237.6 kcal/wk (176.8 kcal/d) in MOC (from 5835.3 to 4597.7 kcal/wk), and in MYC, PAEE decreased by 1572.5 kcal/wk (224.6 kcal/d), from 7690.5 to 6118.0 kcal/wk.

Conclusion: There was a significant reallocation of time by mothers from PA (eg, housework) to SED (eg, watching television) between 1965 and 2010. Given the essential role of PA for health and the potential for the intergenerational transmission of obesity and obesogenic behaviors, these results suggest that maternal inactivity may be an important target for the primary prevention of chronic noncommunicable diseases and obesity.

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Over the past 50 years, there have been large and significant decrements in physical activity (PA)[1-5] with concomitant increments in obesity and many chronic noncommunicable diseases (NCDs) in women and children (eg, type 2 diabetes mellitus and nonalcoholic fatty liver disease).[5-8] Given that PA is an absolute prerequisite for health and wellness,[4,9-11] it is not surprising that inactivity is now a leading cause of death and disease in developed nations.[4,12] While research has revealed that personal behaviors (eg, PA) are major determinants of an individual's health and energy status (eg, obesity),[13-16] an emerging body of epidemiological and experimental evidence suggests that maternal behaviors may also play a role in determining the developmental trajectories (ie, physiologic and behavioral) that determine the risk of obesity and chronic NCD in children.[17-21]

Although women are significantly less active and more sedentary than they were 50 years ago,[1,2,22-25] trends in the reallocation of time by mothers from PA to sedentary behaviors (SED) and the resulting changes in maternal PA energy expenditure (PAEE) have not been addressed systematically. The purpose of this study was to quantify maternal behavior via an examination of 45-year trends in maternal allocation of time to PA and SED and consequent PAEE. This analysis may provide essential contextual evidence by which to inform public policy on the primary prevention of obesity and chronic NCD.

PARTICIPANTS AND METHODS

Allocation of Time

Data on PA, SED, and time allocation were derived from the American Heritage Time Use Study (AHTUS).[26] The AHTUS is a nationally representative database produced via the harmonization of multiple time-use data

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sources for comparative analyses of trends in paid and unpaid work[26,27] and consists of more than 50,000 diary days spanning 1965-2010. The number of weighted diaries from mothers with children 18 years or younger available for analysis was 586 for the 1960s, 1050 for the 1970s, 539 for the 1980s, 1313 for the 1990s, 10,103 for 2003-2005, and 13,846 for 2006-2010.

Time-use data are considered more reliable and accurate for nonoccupational PA than other surveillance systems[28] and allow examinations of the reallocation of time between activities. For example, if mothers spend less time performing housework, they may spend more time exercising or watching television (TV).

PA and SED Variables

Time-use data on more than 90 behavioral subcategories for mothers with children 18 years or younger were examined for changes in time allocation. Subcategories that exhibited statistically significant trends were retained for analyses and divided into 2 groups: physically active behaviors (ie, PA) and SED. Behavioral subcategories that did not exhibit statistically significant trends were excluded from further analyses. Physically active behaviors were operationally defined as the aggregate time spent in meal preparation and cleanup (eg, cooking, washing dishes), general cleaning (eg, vacuuming), clothing maintenance (eg, laundry), general child care and playing with children, and leisure time PA, defined as sport and exercise participation. SED were the aggregate time spent in screen-based media use (ie, nonoccupational use of TV or computer) and the time spent in a vehicle.

Relative Allocation of Time Across the Study Period

The relative allocation of time to PA and SED for each survey cohort (ie, 1960s, 1970s, etc) was examined by subtracting SED hours per week (SED-h/wk) from PA hours per week (PA-h/wk) (ie, PA-h/wk − SED-h/wk) for each respondent. The resulting value provided a measure of the relative allocation of time to PA and to SED (ie, the number of hours spent in energetically costly activities vs sedentary pursuits). A positive value indicates more time spent in PA than SED, and a negative value indicates the converse.

Maternal Subcategories and Employment Status

Women were grouped in 2 categories on the basis of the age of their children: mothers with older children (MOC) (>5 to ≤ 18 years) and mothers with younger children (MYC) (≤ 5 years). Mothers who had at least one child 5 years or younger were included only in the MYC group, regardless of the age of their other children. These categories provided data on the PA required when children of varying ages are present and capture maternal behaviors spanning from the antenatal period through adolescence.

Employment impacts the allocation of time[24]; therefore, mothers were categorized by employment status as employed or unemployed, based on self-reported work (in hours per week). Full-time employment was defined in the harmonized data sets as more than 21 hours of paid work per week for 1965-1990 and more than 35 hours per week for 1990-2010.[26,27] Employment-related intragroup differences have been examined extensively.[22,23,25] Because the foci of our study were the overall trends in the time allocated to PA, SED, and consequent PAEE, our analyses did not statistically examine employed vs unemployed women. The grouping of participants by employment status was an aid in depicting the longitudinal changes of these respective groups.

Physical Activity Energy Expenditure

Physical activity consisted of numerous tasks of varying intensity. As per previous research, metabolic equivalent tasks (MET) values of 2.8 were assigned to household activities, 2.5 MET for child care, and 4.5 MET for all leisure time PA.[1,29] These values represent the energy expenditure per unit of time based on the Food and Agriculture Organization of the United Nations, World Health Organization, and United Nations University (FAO/WHO/UNU) report on human energy expenditure[30] and the 2011 Compendium of Physical Activities.[29]

Energy Expenditure and Body Mass

Because women of childbearing age were heavier in 2010 than in 1965, increments in the body weight used for the estimation of the PAEE for each survey period were necessary. Because body weights were not included in the AHTUS, increments were calculated from 2 representative

national surveys, the National Health Examination Survey and the National Health and Nutrition Examination Survey, for the age group 19 to 40 years.[31] These surveys are based on representative samples of the civilian noninstitutionalized US population via a complex sampling design. The estimated average body weights applied for each survey period were: 1960s, 62 kg; 1970s, 63 kg; 1980s, 66 kg; 1990s, 70 kg; 2005, 73 kg; and 2010,74 kg. As per previous research on PAEE[1,2] and the 2011 Compendium,[29] the estimated energy expenditure for each activity and time period was calculated from the equation: energy expenditure = (hours in activity per week × MET value for activity × mean body weight).

Statistical Analyses

Data processing and statistical analyses were performed using SPSS version 19.0 (SPSS Inc) in 2013. Decade-to-decade (eg, 1960s vs 1970s) contrasts and trend analyses via linear regression were conducted for the allocation of time to PA, SED, and PAEE. Time was included in the relevant models as a continuous variable. Analyses accounted for the survey design via the incorporation of weighting to maintain a nationally representative sample. All analyses included weighted means; $P<.05$ (2-tailed) was used to signify statistical significance.

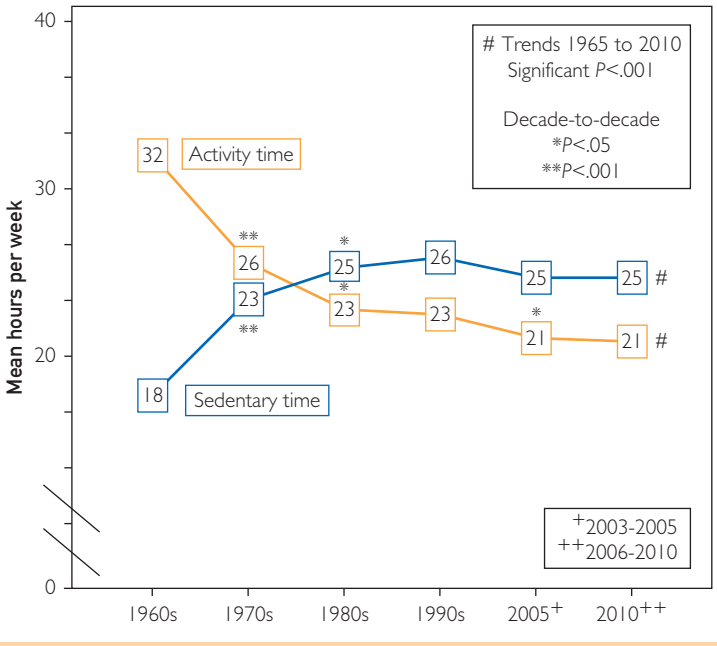

FIGURE 1. Activity and sedentary time, 1965-2010 (mean hours per week, rounded to nearest whole number) in US mothers with older children (>5 to ≤18 years).

RESULTS

Extensive descriptions of the AHTUS population have been published previously.[26,27] The AHTUS sample did not differ substantively from US population demographic characteristics and national statistics with the exception that a greater proportion of the AHTUS respondents were white and of higher socioeconomic status.[26,27]

Time Allocated to PA

Significant trends for decrements in PA-h/wk were evident between 1965 and 2010. The declines were 11.1 h/wk (from 32.0 to 20.9 h/wk; $P<.001$) in MOC and 13.9 h/wk (from 43.6 to 29.7 h/wk; $P<.001$) in MYC. Trends varied by employment status. The decline in unemployed MOC was 13.1 h/wk (from 38.0 to 24.9 h/wk; $P<.001$), while the decline in employed MOC was 5.9 h/wk (from 23.1 to 17.2 h/wk; $P<.001$). The decline in unemployed MYC was 13.6 h/wk (from 48.9 to 35.3 h/wk; $P<.001$), while the decline in employed MYC was 5.1 h/wk (from 26.9 to 21.8 h/wk; $P<.001$). Figures 1 and 2 depict trends in PA-h/wk and SED-h/wk for MOC and MYC from 1965 to 2010, respectively.

Time Allocated to SED

There were significant increments in SED-h/wk between 1965 and 2010 among MOC and MYC ($P<.001$). SED-h/wk increased by 7.0 h/wk, from 17.7 to 24.7 h/wk among MOC ($P<.001$), and SED-h/wk for MYC increased by 5.7 h/wk, from 17.0 to 22.7 h/wk ($P<.001$). The trends in SED-h/wk varied by employment status. Among MOC, SED-h/wk increased by 8.1 h/wk (from 19.2 to 27.3 h/wk) in unemployed mothers ($P<.001$) and by 6.7 h/wk (from 15.6 to 22.3 h/wk) in employed mothers ($P<.001$). Among MYC, SED-h/wk increased by 6.9 h/wk, from 17.4 to 24.3 h/wk, in unemployed mothers ($P<.001$) and by 4.5 h/wk, from 15.9 to 20.4 h/wk, in employed mothers ($P<.001$).

Physical Activity Energy Expenditure

Trends in estimated PAEE for MOC and MYC from 1965 to 2010 are shown in Figure 3.

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Physical activity energy expenditure declined significantly over time in both MOC and MYC ($P<.001$). The estimated decrease from 1965 to 2010 among MOC was 1237.7 kcal/wk (176.8 kcal/d), from 5835.3 to 4597.7 kcal/wk ($P<.001$), and the decrease among MYC was 1572 kcal/wk (225 kcal/d), from 7690 to 6118 kcal/wk ($P<.001$). Corresponding declines by employment status among MOC were 1463 kcal/wk (209 kcal/d) in those unemployed ($P<.001$) and 443 kcal/wk (63 kcal/d) in those employed ($P<.001$). Among MYC, PAEE declined by 1346.6 kcal/wk (192.4/d) in unemployed ($P<.001$) and by 284.3 kcal/wk (40.6 kcal/d) in employed ($P<.001$) mothers.

Trends in Time Reallocation and PA Displacement

SED-h/wk were subtracted from PA-h/wk for each survey period in order to examine trends in the reallocation of time. Trends in the allocation of time from 1965 to 2010 for MOC and MYC are depicted in Figure 4. Negative values indicate more time spent in SED than in PA.

The trends in reallocation of time from PA to SED were significant among MOC and MYC ($P<.001$). Mothers of older children spent 14.2 more hours per week in PA than SED in 1965 but 3.8 more hours per week in SED than in PA in 2010, a reallocation of 18.0 h/wk ($P<.001$). Mothers of younger children spent 26.5 more hours per week in PA than SED in 1965 and 6.9 more hours per week in PA than in SED in 2010, a reallocation of 19.6 h/wk ($P<.001$). Employed MOC spent 7.6 more hours per week in PA than in SED in 1965 but 5.1 more hours per week in SED than in PA in 2010, a reallocation of 12.7 h/wk from PA to SED ($P<.001$). Employed MYC spent 11.0 more hours per week in PA than SED in 1965 but 1.4 more hours per week in PA than SED in 2010, a reallocation of 9.6 h/wk ($P<.001$). Unemployed MOC spent 18.7 more hours per week in PA than in SED in 1965 but 2.4 more hours per week in SED than in PA in 2010, a reallocation of 21.1 h/wk ($P<.001$). Unemployed MYC spent 31.6 more hours per week in PA than in SED in 1965 and 11 more hours per week in PA than in SED in 2010, a reallocation of 20.6 h/wk ($P<.001$). Overall, unemployed MOC and MYC reallocated more than 20 h/wk or almost 3 h/d from PA to SED.

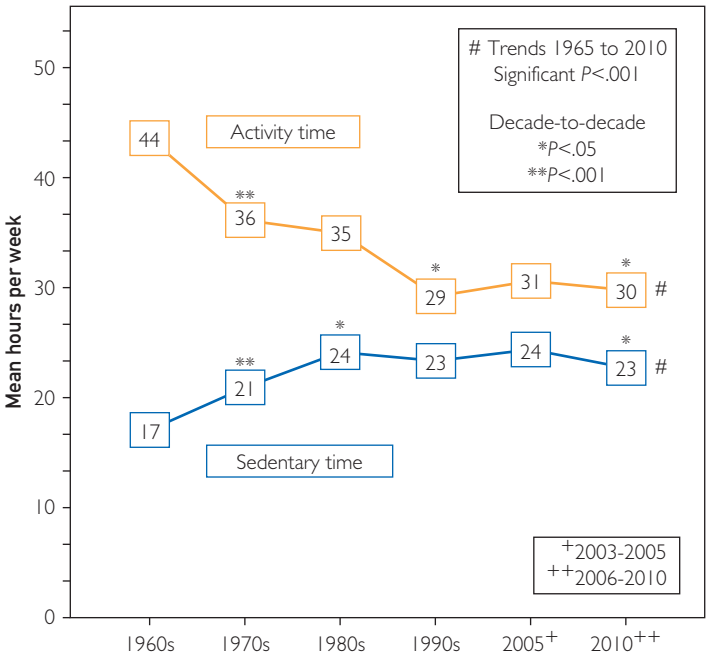

FIGURE 2. Activity and sedentary time, 1965-2010 (mean hours per week, rounded to nearest whole number) in US mothers with younger children (≤5 years).

DISCUSSION

From 1965 to 2010, mothers reported a large and significant reallocation of time from PA to SED (Figures 1 and 4). In 1965, unemployed MOC and MYC were respectively allocating 18.7 and 31.6 more hours per week to PA than SED. By 2010, unemployed MOC were spending more time in SED than PA, and unemployed MYC were spending only 10 more hours in PA than SED (Figure 4). For both unemployed MOC and MYC, this reallocation of almost 3 h/d (>20 h/wk) from PA to SED led to substantial declines in PAEE (Figure 3). From 1965 to 2010, PAEE for all mothers decreased significantly, with MOC decreasing by 176.8 kcal/d (1237.7 kcal/wk) and MYC decreasing by 224.6 kcal/d (1572.2 kcal/week).

These results parallel earlier research that suggests substantial decrements in mothers' PA and concomitantly large increments in SED over the past 50 years.[24,25] The patterns of PA and SED as depicted in Figures 1 and 2 suggest that maternal PA may have reached a nadir, with both MOC and MYC achieving plateaus in the 1990s. This apparent equilibrium between PA and SED may be the result of the

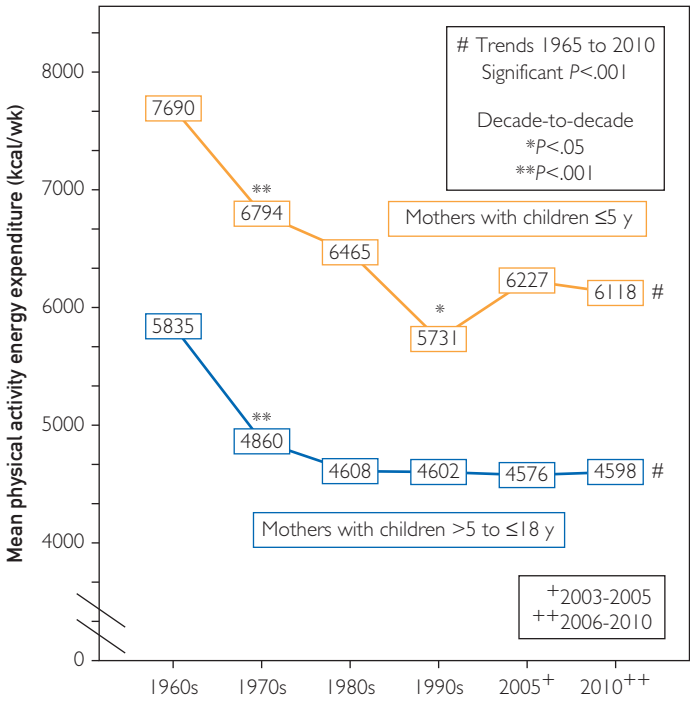

FIGURE 3. Physical activity energy expenditure (mean kilocalories per week) in US mothers, 1965-2010.

zero-sum nature of time, with the time allocated post-1990 to PA by MOC and MYC representing requisite minimums when children of varying ages are present in the household (ie, younger children require more PA than older children).

Maternal PA, SED, and Health

Although unemployed mothers experienced much larger declines in PA and PAEE and increases in SED than employed mothers, all groups reported reductions in PA and increments in SED. The major drivers of these trends were decreases in housework and food preparation/postmeal cleanup and increases in screen-based media use (eg, watching TV). This reallocation of time may have had an impact on mothers' health and weight management. Research has revealed that men who spent more than 23 h/wk in SED (ie, TV viewing and time in a vehicle) had a 64% greater chance of dying from cardiovascular disease (CVD) than men who reported spending less than 11 h/wk in SED.[32] In this same cohort, high levels of PA were protective against the increased risk of CVD mortality induced by high levels of SED. Note that in the current study, all categories of mothers reported significantly less PA in 2010 than in 1965 and allocated significantly more time (ie, >20 h/wk) to SED. The convergence of low levels of PA and high levels of SED may have effects on the risk of obesity, CVD, and other chronic NCDs.

Maternal Employment PA, SED, and Health

A dominant factor in the overall reduction in maternal PA appears to be the change in women's social roles. Early in the 20th century, women allocated most of their time to nonpaid but energetically costly activities (eg, housework). By the 1950s, women increased the amount of time allocated to paid employment,[33] and by the beginning of the 21st century, women's full-time employment had increased from 34% to 60%,[34] with the full-time employment of mothers with young children increasing from 19% to 57%.[35,36] For many women, the transition from nonpaid activities to paid activity (ie, employment) resulted in significant decreases in PA and increases in SED.[24,25,36] This sociocultural evolution led to a decrease in the time women allocated to all aspects of PA and domestic life.[24,37] For example, employed mothers performed less child care (about 8 h/wk) and less housework (about 10 h/wk) and achieved less sleep (about 3 h/wk) than stay-at-home mothers,[25,35,37] and recent research suggests that unmarried employed mothers are less physically active than married employed mothers and employed women without children.[38]

Maternal Inactivity, Obesity, and Health

There are insufficient data and no valid unitary models that allow extrapolations from our results to population-level weight gain and recent increases in the prevalence of obesity and/or chronic NCD. Nevertheless, the large and significant declines in PA and PAEE parallel the increments in SED. This suggests that as mothers allocated less time to PA, the resultant free time has been disproportionately allocated to SED such as screen-based media use (eg, TV and computer). As such, the absence of valid population-level data on increases in energy intake (ie, increased caloric consumption)[39-41] and a growing body of research on multiple domains of PA (eg, housework,[1,42]

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occupation,[2] transportation,[43] and SED[44]) support the speculation that inactivity may be the major contributor to the increase in body weight, obesity, and energy expenditure–dependent chronic NCDs (eg, type 2 diabetes mellitus) during the latter half of the 20th century. In fact, the decrement in PAEE appears to have been so large that the prevalence of overweight and obesity would be significantly higher if compensatory responses (eg, decreased energy intake) were absent.

Intergenerational Transmission of Inactivity and Disease

It is unequivocal that the intrauterine, postnatal, and childhood environments engendered via maternal behaviors have profound influences on the development of children,[19,20] inclusive of the risk of obesity and chronic NCD in later life.[19,45] While speculative, we posit that because a mother's PA and SED affect the environments to which her progeny are exposed (eg, intrauterine milieu and family social setting),[18,45,46] there exists the potential for the intergenerational transmission of pathophysiology[20,21,47] and obesogenic lifestyle behaviors from mothers to children.[48-50] These potential effects may be induced via direct physiologic effects on the fetus in utero[21,47,51] and/or the social transmission of SED (eg, TV viewing) from mothers to infants and children via social learning and observational and/or classical conditioning.[45,48,49,52,53]

There is growing evidence that body composition and energy metabolism are programmed in utero.[21,54-56] Because PA is a strong determinant of nutrient partitioning (ie, the metabolic fate of consumed nutrient energy to storage or oxidation[57-61]), preconception maternal inactivity may be causal to pregravid obesity[62,63] and when combined with prenatal inactivity may alter the programming of fetal body composition and energy metabolism, leading to an increased risk of obesity and chronic NCD. Additionally, there is strong evidence that maternal TV viewing behaviors influence children's TV viewing behaviors,[52] and large-scale epidemiological studies have revealed that one of the strongest determinants of obesity and cardiometabolic risk factors in later life is TV viewing as a young child.[64] Given that most pregnant women spend more than 50% of their waking hours in SED and more than 15% of pregnant women report spending more than 5 h/d in screen-based media use,[65,66] it can be posited that, as with the intergenerational transmission of smoking behavior,[53] children raised by inactive, sedentary, and therefore unhealthy caregivers may have an increased risk of being inactive, sedentary, and unhealthy as adults.

Contrary to the influence of maternal behaviors on the intrauterine environment, paternal behaviors have no direct influence on the intrauterine environment, but they may play a small role in the development of obesogenic behaviors in later childhood. While fathers report allocating more time to child care over the past few decades,[35-37] it is trivial when compared with mothers' allocation. As such, the influence of maternal behaviors is paramount from conception through early childhood because, in addition to controlling the intrauterine environment, mothers are the primary caregivers for most children throughout early life. For example, as of 2007, there were more than 5.6 million stay-at-home moms and fewer than 165,000 stay-at-home dads.[67,68]

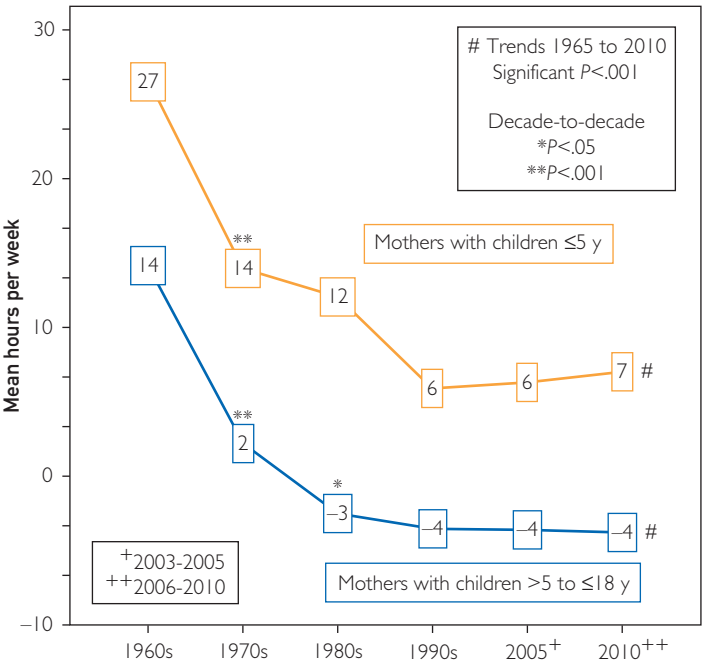

FIGURE 4. Time reallocation (mean hours per week spent in physically active behaviors minus mean hours per week spent in sedentary behaviors; numbers rounded to the nearest whole number) in US mothers, 1965-2010. Negative values denote more time spent in sedentary than in physically active behaviors.

Implications for Public Health Policy

The 2008 Physical Activity Guidelines for Americans were based on epidemiological evidence spanning many decades.[69] If the PA levels necessitated by daily life have been decreasing over that period (as our results and other research suggests[1-3,24,25]), it raises the possibility that recommendations may need to be revised to account for recent trends. For example, the estimated reductions in PA for unemployed mothers (>20 h/wk) and PAEE (1237.7 and 1572.5 kcal/wk for MOC and MYC, respectively) would not be adequately compensated by meeting the federal PA recommendations of 2.5 h/wk of moderate-intensity PA (about 560 kcal/wk).

Given the evidence that preconception exercise ameliorates the reproductive complications of maternal obesity and that exercising throughout pregnancy is protective against excessive prenatal weight gain, gestational diabetes, and other outcomes (eg, birth weight, fetal body composition, and maternal postpartum depression),[70-73] population health may be improved considerably with policies targeting the preconception activity levels of potential mothers.

Strengths and Limitations of the Study

This study represents the first detailed analyses of trends in maternal PA, SED, and PAEE derived from historical time-use databases. Physical activity energy expenditure was derived using an empirically supported protocol for the translation of PA into PAEE.[29] Our results on the allocation of time to PA and SED are in agreement with those from other researchers.[1,22,25,26,74] Furthermore, we used a conservative estimate of the mean intensity of PA based on previous research[1] and the convention established by the FAO/WHO/UNU in 1985[30] and the Compendium of Physical Activities.[29] Importantly, our results on the reallocation of time from PA to SED are bolstered by investigations independent of the AHTUS data sets reporting decreased household PA[75] and increased TV viewing.[76,77]

Potential limitations of the study are the use of harmonized data sets and self-reported data. The harmonization process, which was not performed by our laboratory, is complex but empirically robust. There are hundreds of peer-reviewed publications and academic texts based on the harmonized data sets.[78] The biases associated with self-reported data are not inconsequential. Those induced via demand characteristics, social desirability, and the cognitive burden of recording the allocation of time limit our results.

Many aspects of sociocultural evolution (eg, second-wave feminism) may have affected the reporting of behavior. It can be posited that some forms of PA were more likely to be overestimated in the earlier decades (eg, housework), while other activities are more likely to be overreported in the latter decades as the social landscape evolved (eg, child care, exercise).[79] Nevertheless, some biases may be omnipresent and stable and may not be a threat to our analysis of trends. For example, TV viewing was not considered a socially desirable activity across the study period[77]; as such, self-reported increments in screen-based media use suggest that trends may be less affected than analyses of static cross-sectional data.

The analysis accounted only for the time allocated to PA and SED and not how technological advances may have altered PAEE. Prior research suggests higher PAEE estimates for specific components of PA[80] than either the 2011 Compendium[29] or the FAO/WHO/UNU report.[30] Additionally, an a priori assumption was that playing with children (ie, a subcategory of PA) was an energetically demanding task. If mothers were sitting while reporting that they were playing with children, that time would be considered SED rather than PA. Nonetheless, these limitations do not considerably diminish our estimates of the decrement in PA-h/wk and suggest an underestimation of the decrement in PAEE that supports our overall interpretation of trends for decreasing PA and increasing SED.

CONCLUSION

This study revealed a significant reallocation of time by mothers from PA (eg, housework) to SED (eg, watching TV) between 1965 and 2010. The confluence of our results and other research suggests that inactivity has increased significantly over the past 45 years and may be the greatest public health crisis facing the world today. With each passing generation, mothers have become increasingly physically inactive, sedentary, and obese, thereby potentially predisposing children to an increased risk of inactivity, adiposity, and chronic NCD.

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As such, maternal inactivity may be an important target for the primary prevention of chronic NCDs and obesity. Until the intergenerational cycle of unhealthy lifestyles is interrupted, inactivity will continue to be one of the leading causes of morbidity and mortality in the world.

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Dr Archer had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Drs Archer and Blair participated in the initial concept and design of this project. All statistical analyses and calculations were performed by Dr Archer. The interpretation was performed by Drs Archer and Blair with assistance from all the other authors. Dr Archer drafted the manuscript, and all the authors participated in the critical review and multiple revisions. Dr Blair provided study supervision.

Abbreviations and Acronyms: **AHTUS** = American Heritage Time Use Study; **CVD** = cardiovascular disease; **FAO/WHO/UNU** = Food and Agriculture Organization of the United Nations, World Health Organization, and United Nations University; **MET** = metabolic equivalent tasks; **MOC** = mothers with older children; **MYC** = mothers with younger children; **NCD** = noncommunicable disease; **PA** = physical activity; **PA-h/wk** = hours of PA per week; **PAEE** = PA energy expenditure; **SED** = sedentary behaviors; **SED-h/wk** = hours of SED per week; **TV** = television

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Potential Competing Interests: Dr Blair receives book royalties (<$5000/y) from Human Kinetics; honoraria for service on the scientific/medical advisory boards for Clarity Consultants, Technogym USA Corp, Santech, and Jenny Craig; and honoraria for lectures and consultations from scientific, educational, and lay groups, which are donated to the University of South Carolina or not-for-profit organizations. Dr Blair is a consultant on research projects with the University of Texas Southwestern Medical School and the University of Miami. During the past 5-year period. Dr Blair has received research grants from The Coca-Cola Company, the National Institutes of Health, and the Department of Defense.

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