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Use of Time and Energy on Exercise, Prolonged TV Viewing, and Work Days

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Abstract

Introduction: The goal of this study was to describe differences in time use and energy expenditure associated with exercise, prolonged TV viewing, and work days in a longitudinal study of older adults.

Methods: Participants were 1,020 adults who completed previous-day recalls that provided a profile of the use of time in sedentary and physical activity. Time use and physical activity energy expenditure were predicted for each type of day (exercise, prolonged TV, work) using linear mixed models, adjusting for age, sex, season of the year, and day of the week. Data were collected in 2012–2013; analysis was completed in 2017.

Results: Exercise days had less sedentary time (−0.37 hours/day) and light activity (−0.29 hours/day), and less household, work, and shopping activities, such that the increase in total physical activity energy expenditure on exercise days (2.83 MET-hours/day) was only about half that expended during exercise (5.98 MET-hours/day). Prolonged TV viewing days had more total sedentary time (0.86 hours/days) and less light (−0.45 hours/day) and moderate–vigorous intensity activity (−0.41 hours/day), and thus lower total physical activity energy expenditure (−2.43 MET-hours/day). Work days had less sleep (−0.91 hours/day) and more total sedentary time (1.32 hours/day).

Conclusions: Exercise days had more physical activity energy expenditure, but because of reductions in other activities, only about half of the energy expended during exercise was added to total daily physical activity energy expenditure. Prolonged TV viewing days had less physical activity energy expenditure and less moderate–vigorous activity. These findings provide new

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insights into possible compensation associated with exercise, and suggest a strong link between TV viewing and physical inactivity.

INTRODUCTION

Lack of exercise and excessive sitting time, particularly prolonged TV viewing, have been associated with elevated risk for mortality and several chronic diseases.[1-4] The emergence of sedentary behavior as a risk factor distinct from exercise has prompted physical activity researchers to begin to investigate the health risks and benefits of replacing time spent in one type of behavior for another.[5,6] Exercising or sitting and watching TV for an hour shrinks time available for other pursuits, and time use exchanges associated with these behaviors may influence daily physical activity energy expenditure (PAEE) and ultimately health. Although time use researchers have investigated the trade-offs between sleep[7] and TV viewing[8] on other daily activities, much less is known about how exercise participation influences time spent in other behaviors, or how prolonged TV viewing influences daily PAEE. A more detailed understanding of these behavioral interrelationships could provide new insights into potential compensation associated with exercise training,[9,10] as well as the extent to which physical inactivity may mediate the associations between prolonged TV viewing and poor health.[11-13]

Accordingly, the primary objective of this report is to quantify differences occurring in the amount and type of sedentary behavior and physical activity and, consequently, energy expenditure on exercise and prolonged TV viewing days. Because employment influences physical activity levels[14] and daily time use, the secondary goal is to examine whether and how work days influenced time use and PAEE. To do this, detailed activity information from over 5,000 previous-day recalls in older adults was used. The authors first describe how adults spend their time and energy and then examined differences in time use and PAEE on days where they exercised, watched TV more than 2 hours, and worked for 4 hours or more.

METHODS

Study Sample

The Interactive Diet and Activity Tracking in AARP (iDATA) study was designed to evaluate diet and physical activity measures suitable for use in epidemiologic studies.[15] Participants were a convenience sample of AARP members (aged 50–74 years) from Pittsburgh, Pennsylvania, who spoke English, had Internet access, were not on a weight-loss diet, had a BMI <40, and were free of major medical conditions and mobility limitations. Initial contact was made via an automated phone call and invitation letter directing those interested to contact the study (Appendix Figure 1, available online). The study was approved by the National Cancer Institute Special Studies IRB. Consented participants completed three clinic visits over 12 months (2012–2013) and completed several diet and physical activity measurements. Appendix Table 1 (available online) shows the overall study design. Individuals who completed the full study received $450.

Measures

The authors used the Activities Completed Over Time in 24 Hours (ACT24) previous-day recall. ACT24 is an Internet-based previous-day recall designed to estimate total time (hours/day) spent sleeping (in bed), sedentary (sitting or reclining), engaged in physical activity, and energy expenditure associated with these behaviors (MET-hours/day).[15] Participants were asked to complete six recalls over 12 months (every other month) on a randomly selected day in the target month. To complete ACT24, respondents select from 213 individual activities from 13 broad categories; record the duration of each; and provide additional details, including body position. Sedentary behaviors were defined as those performed during the waking day (out of bed) while sitting or reclining and that require little energy expenditure, typically <1.8 METs,[16,17] whereas active behaviors were those involving an upright posture or that had higher MET levels.[16,17] Time reported in light (non-sedentary <3 METs), moderate (i.e., 3–5.9 METs), and vigorous-intensity activity (i.e., ≥6 METs) was also calculated. PAEE (MET-hours/day) was calculated as the sum of light, moderate, and vigorous activity. To contextualize time use in each type and intensity of behavior the authors mapped ACT24 data to relevant time use categories.[18] ACT24 has been found to be reasonably accurate in estimating PAEE (plus or minus 10% of doubly labeled water), and sedentary time (plus or minus 3% of activPAL), and correlated with light (r =0.34), and moderate–vigorous activity (r =0.47) versus an accelerometer.[15]

Statistical Analysis

Participant characteristics and the amount of time reported in each of the main time use categories are described, as well as the proportion of participants reporting ≥ 1 day of exercise (any), prolonged TV viewing (≥2 hours/day), or work (≥4 hours/day). The authors elected to use ≥ 2 hours/day to classify prolonged TV days because TV viewing time greater than this is associated with increased mortality.[1,13] The authors also used ≥4 hours/day of reported work to capture substantive part-time and full-time work days. Sedentary and active time and PAEE by intensity are also described.

Overall, there were 5,232 valid recalls from 1,020 participants (≅ 5.1 recalls per participant). The association between outcomes and the type of day (i.e., a binary zero or one variable indicating either an exercise, prolonged TV viewing, or work day) were evaluated using a linear mixed model with a subject-specific random effect, adjusting for age, sex, season of the year, and day of the week. The outcomes of interest were time use (e.g., sleep, waking, active, and sedentary time) and PAEE variables (i.e., total, light, moderate, vigorous). Stratified analysis by age (< 65 and ≥65 years) and by BMI (<30 and ≥30 kg/m^2) was also conducted. Analyses were completed using Stata/SE, version 14.1.

RESULTS

Participants were aged 63 years and had BMIs of 28 on average (31% obese) and reported an average 16-hour waking day (Table 1). The greatest amount of time use (both active and sedentary combined) was reported in leisure pursuits, followed by household, personal care, working, and transportation (Table 1). The proportion of participants of who reported at least one type of day and the average number of days of each type in all participants were as follows: exercise (74%, mean 2.12 [SD=1.87] days), prolonged TV viewing (81%, mean 2.48 [SD=1.90] days), and work (49%, mean 1.28 [SD=1.64] days).

In describing how participants spent their time and energy, the study found the greatest amount of waking time was spent in sedentary behavior, with men reporting more sitting (10.3 hours/day) than women (9.5 hours/day; Figure 1D). About 50% of sedentary time was reported during leisure time, and other sitting time was distributed between work, transportation, personal care, and household activities. On work days, sedentary time at work was the largest contributor to total sitting time (46%) and leisure time sitting accounted for only about 27% of total sedentary time (Appendix Figure 2B, available online).

Women reported more total active time than men (6.5 vs 5.8 hours/day, $p < 0.01$), and more non-sedentary light activity, whereas men reported more moderate–vigorous activity (Figure 1A). There was no sex difference in PAEE (Figure 1B). Light activity accounted for 61%–76% of all active time in men and women, and 44%–63% of overall PAEE, an amount of expenditure that was similar to that derived from moderate-intensity activity (31%–43%). The greatest amount of PAEE in men and women was accumulated from household activity (36%–40%), leisure time (22%–27%), work (11%–15%), personal care (9%–12%), and shopping/doing errands (7%–9%; Figure 1C). On work days, there was a small decrease in overall PAEE even though work-related activities emerged as the largest source of activity (Appendix Figure 3B, available online).

Next the authors examined how time use differed, or was exchanged, on days with and without exercise and prolonged TV viewing. For example, on exercise days, participants reported an average of 1.33 hours/day of exercise, time which was exchanged from other time use categories, including reduced waking time (−0.04 hours/day), sedentary time (−0.37 hours/day), and light-intensity activity (−0.29 hours/day), and an increase in moderate–vigorous activity (0.62 hours/day; Appendix Figure 4, available online). The sum of time differences from these categories equals the 1.33 hours/day of exercise (with rounding error), and time differences between exercise and non-exercise days are described by the regression coefficients (β) reported in Table 2. In addition to the associations noted above, the study also found that exercise days had more time spent in personal care and leisure time activities, but these increases were offset by reductions in household, work, shopping, and other physical activities (Table 2). Exercise days were characterized by small reductions in total sedentary time, which was exchanged from the household, transportation, and shopping categories, but surprisingly not from leisure time sitting, or TV viewing.

On prolonged TV viewing days, participants reported 2.9 hours/day more sedentary TV viewing (Table 2). Prolonged viewing days did not have different sleep or waking times, but they had less total active time (−0.81 hours/day), lost from both light (−0.45 hours/day) and moderate–vigorous activity (−0.41 hours/day). Losses were derived from personal care, leisure, transportation, and other activities. Prolonged viewing days had more total sedentary time (0.86 hours/day), primarily during leisure time (2.0 hours/day), and less sitting time at work, and in transportation.

On work days, participants reported working for an average of 7.2 hours/day, and on these days sleep time was reduced by −0.91 hours/day and waking time was increased a comparable amount (Table 2). Work days also were associated with less total activity (−0.42 hours/day) even though active time at work was higher than for non-work days (2.56 hours/day). Reductions were noted for light activity and in household, leisure, and shopping activities. Total sedentary time on work days was increased (1.32 hours/day), driven primarily by sitting at work, with a number of off-sets in most other time use categories (Table 2).

Table 3 reports differences in PAEE (MET-hours/day) associated with each type of day. On exercise days, the amount of energy expenditure from exercise was estimated to be 5.98 MET-hours/day, yet only about half of this amount was added to total PAEE (2.83 MET-hours/day), because of reductions in physical activity in other life domains (Table 3). Notably, prolonged TV days had 2.43 MET-hours/day less total PAEE, with losses coming from both moderate–vigorous (−1.56 MET-hours/day) and light-intensity activity (−0.98 MET-hours/day). Work days had substantially more PAEE at work, but less PAEE in most other categories, leading to a nonsignificant reduction in total PAEE of −0.72 MET-hours/day on work days.

Stratified analysis did not reveal major differences in the primary findings by age or obesity status (Appendix Tables 2 and 3, available online).

DISCUSSION

This study describes how older adults used their time and energy in daily life, as well as the associations between exercise, prolonged TV viewing, and work days with a variety of behavioral outcomes using more than 5,000 detailed previous-day recalls from more than 1,000 participants.[15] As expected, sedentary behavior was the most common class of behavior reported, and 50% of the approximately 10 hours/day of daily sitting time was reported in leisure time. Leisure time sitting would appear to be a large and high-value target for interventions designed to replace sedentary time with physical activity.[19] This study also found that time in the day for exercise was associated with less sedentary time and light-intensity activity and that only about half of the energy expended during exercise was added to total PAEE. Prolonged TV viewing was associated with substantial reductions in total PAEE, and 64% of this decline was from moderate–vigorous intensity physical activity. Finally, work days were associated with less sleep and more total sedentary time.

Whether exercise training is associated with compensatory reductions in non-exercise activity has been controversial. Some studies show no evidence of compensation,[9,20-22] whereas others report reductions in non-exercise activity,[23-25] with some tendency for compensation to be reported more often in adults aged more than 50 years,[23-27] but not always.[21] This study of adults aged 50–74 years makes a unique contribution because of its detailed examination of time use on days with and without exercise in the same individuals, and the results were interpreted to reflect short-term (day to day) rather than the longer-term changes that have been evaluated in most other studies.[9] Interestingly, only about half of the energy expended during exercise (5.98 MET-hours/day) was reflected in the increase in total

PAEE of 2.83 MET-hours/day on exercise days. This is consistent with results of Wasenius et al.[25] who noted, using a detailed questionnaire in older adults, that for each 1 MET increase in aerobic activity (Nordic walking), non-exercise activities were reduced by 0.56 METs. Similarly, Morio and colleagues,[23] using physical activity diaries and the factorial method to estimate energy expenditure, found progressive interval training in the elderly did not increase total daily PAEE because of an 8% reduction in non-exercise activities, primarily because of decreases in daily walking outside of training. In a study designed to investigate time use changes associated with exercise, Gomersall et al.[28] also employed previous-day recalls and found supervised exercise to be associated with an increase in active transport and personal care, and reductions in TV viewing and household chores. In contrast to Gomersall and colleagues,[28] the present study found no changes in TV viewing or leisure-time sitting on exercise days. Ideally, one would like to substitute a healthy behavior (exercise) for a less healthy behavior (TV viewing), but in these data this was not the case. The results indicating that exercise days had less sedentary time and less non-exercise physical activity could reflect simple time displacements on exercise days, different behavioral choices on exercise days, or a combination of both. More research is needed to understand the extent to which exercise may alter behavioral choices in other parts of the day, and more generally to understand the interpersonal and environmental determinants of physical activity.[29,30]

In the U.S., 79% of adults report watching TV on a given day, and on these days reported viewing time was 3.5 hours/day on average,[31] suggesting that prolonged TV viewing is quite prevalent in the population. Viewing 2 or more hours/day of TV has been linked to increased risk for early mortality and cardiovascular disease, but whether these associations were due to the displacement of physical activity or other confounding factors is not well understood.[11] Current results suggest that prolonged TV viewing is associated with a substantial reduction in daily PAEE (2.43 MET-hours/day), an amount that is nearly as great as the increase in PAEE found to be associated with exercise (2.83 MET-hours/day). Furthermore, 64% of the reduction in PAEE on prolonged TV days was from health-enhancing moderate–vigorous intensity activity. The present study extends previous research, which has linked prolonged TV viewing to increased accelerometer-measured sedentary time[32] and shown that reductions in TV viewing can increase physical activity,[33] by providing a detailed description of how use of time and energy in older adults may change on days with prolonged TV viewing. The finding that the displacement of physical activity by prolonged TV viewing is substantial and includes reduced moderate–vigorous activity suggests that physical inactivity may be a key behavioral mediator of the adverse effects of TV on cardiometabolic diseases and early mortality,[1,34] but additional research is needed to confirm these findings in other study populations.

These results describing the association between work days and the type and amount of physical activity in other life domains were largely consistent with previous studies that show work days to be associated with increased total sedentary time and reduced light-intensity activity in office workers in the United Kingdom[35] and Australia.[36] Similarly, work days were associated with shorter sleep times in a large nationally representative survey of U.S. adults[7] and a large cohort of Australian women.[37] The finding that on work days occupational sitting accounted for 46% of total daily sitting is also consistent with Jans and colleagues,[38] who highlighted the sedentary nature of many work environments in Western countries. Present results reinforce the notion that work time can be an important contributor to total sedentary time; highlighting the potential for workplace interventions to reduce sitting time and increase physical activity.[39,40]

Limitations

The main strength of this report was its novel use of the contextually rich data captured by the previous-day recall (ACT24), an instrument that has been shown to be reasonably accurate and valid for estimating total physical activity and sedentary time.[15] The ability to examine active and sedentary behaviors by type and intensity allowed the authors to describe differences in time use and energy expenditure in response to exercise, prolonged TV, and work days in a large population of older adults adjusting for season and day of the week. This study also had a number of weaknesses. ACT24 has been validated for total active and sedentary time and PAEE,[15] but less is known about the validity of light and moderate–vigorous activity or for specific types of activities. Although adults can provide useful information about activity types and context in comparison to direct observation,[41] more validation work is needed to understand the accuracy of specific time use categories with this method. The iDATA study was a convenience sample of adults living in Pittsburgh, Pennslyvania, which may limit generalizability of the findings. Also, this study was observational in nature and therefore causal relationships between day type and time use cannot be inferred. Changes from day to day were evaluated rather than long-term changes in behavior. Finally, the authors relied on standard MET values rather than measured energy expenditure to estimate PAEE, so the results are subject to the limitations of METs.[42]

CONCLUSIONS

This study suggests that only about half of the energy expended during exercise may be added to daily PAEE in older adults, and that prolonged TV viewing may have a more profound effect on daily PAEE and moderate–vigorous intensity activity than previously recognized. These findings inform the design of more efficient exercise interventions that minimize compensation and increase daily energy to promote weight loss and improved health. Furthermore, these results provide new information consistent with the idea that physical inactivity could play a central role in explaining the link between prolonged TV viewing and poor health, and also highlight the potential for minimizing TV time in order to increase physical activity. To date, there has been limited research into time and energy exchanges associated with exercise, prolonged TV viewing, and work days, and further research in this area[29,30] on the complex interplay and determinants of human behavior appears warranted.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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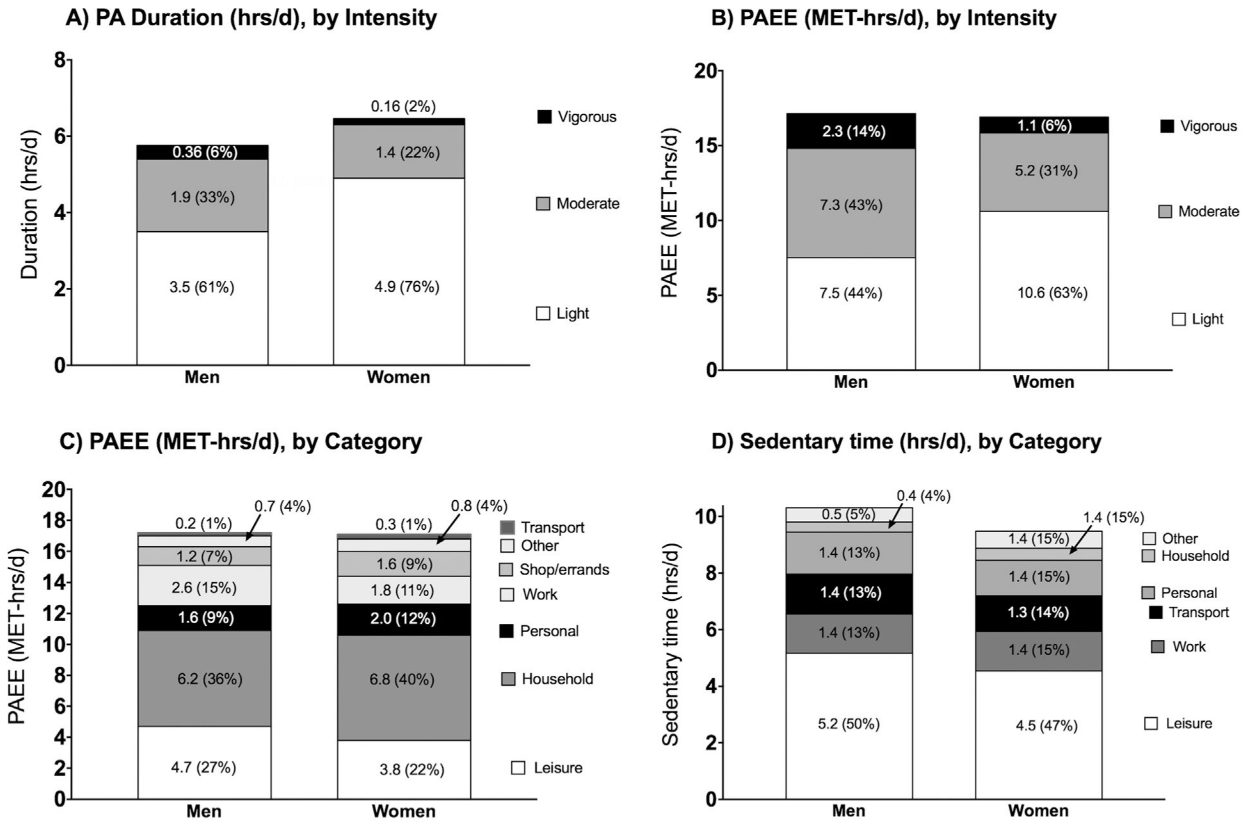

Figure 1.

Description of physical activity and sedentary time in men and women, iDATA Study, 2012–2013. (A) Physical activity duration (hours/day), by intensity. (B) PAEE (MET-hours/day), by intensity. (C) PAEE (MET-hours/day), by category. (D) Sedentary time (hours/day), by category.

iDATA, Interactive Diet and Activity Tracking in AARP; PAEE, physical activity energy expenditure.

Table 1.

Participant Characteristics and Overall Time Use by Category, iDATA Study, 2012–2013

Characteristics	All participants (*n*=1,020)	Men (*n*=508)	Women (*n*=512)	*p*-value[a]
Age, M (SD)	63.1 (6.0)	63.9 (5.8)	62.3 (6.1)	**<0.01**
BMI, M (SD)	28.0 (4.6)	28.3 (4.2)	27.7 (4.9)	**0.04**
Obese, *n* (%)	313 (31)	149 (29)	164 (32)	0.35
Sleep/in-bed time, hours/day, M (SD)	8.0 (1.1)	7.9 (1.0)	8.1 (1.1)	0.05
Waking time, hours/day, M (SD)	16.0 (1.1)	16.1 (1.0)	15.9 (1.1)	**0.04**
No. of waking activities/day, M (SD)	23.9 (7.9)	22.6 (7.7)	25.2 (7.9)	**< 0.01**
Time use by category, hours/day, M (SD)				
Personal care	2.2 (0.8)	2.3 (0.8)	2.2 (0.9)	0.30
Household activities	2.6 (1.7)	2.3 (1.7)	3.0 (1.7)	**<0.01**
Work (for pay)	2.1 (2.6)	2.2 (2.6)	2.0 (2.5)	0.27
Leisure	6.2 (2.3)	6.6 (2.3)	5.8 (2.1)	**<0.01**
Transportation	1.4 (0.9)	1.5 (0.9)	1.3 (0.8)	**0.02**
Shop/errands	0.7 (0.6)	0.6 (0.6)	0.8 (0.7)	**<0.01**
Civic/religious/education	0.4 (0.7)	0.3 (0.6)	0.4 (0.8)	**0.03**
Other (not classified)	0.4 (0.7)	0.4 (0.6)	0.4 (0.7)	0.79
Participant day types, *n* (%)				
Exercisers[b]	755 (74)	386 (76)	369 (72)	0.15
TV watchers[c]	821 (81)	437 (86)	384 (75)	**<0.01**
Workers[d]	495 (49)	255 (50)	240 (47)	0.29

Note: Boldface indicates statistical significance ($p<0.05$).

[a]Test of differences by sex.

[b]Reported 1+ day of exercise or sports.

[c]Reported 1+ day of TV watching of 2 or more hours.

[d]Reported 1+ day of work (4+ hours/day).

iDATA, Interactive Diet and Activity Tracking in AARP; No., number.

Table 2.

Difference in Time Use (Hours/Day) in Physically Active and Sedentary Behaviors by Day Type, iDATA Study, 2012–2013

	Difference in time use (hours/day) by type of day[a]					
	Exercise (any)		TV (2+ hours/day)		Work (4+ hours/day)	
Time-use outcomes	**β**	**SE**	**β**	**SE**	**β**	**SE**
Sleep/in-bed time (hours/day)	0.05	0.05	−0.03	0.05	**−0.91**	0.06
Waking time (hours/day)	−0.04	0.05	0.04	0.05	**0.90**	0.06
Active time (hours/day)						
Total active time	**0.33**	0.08	**−0.81**	0.08	**−0.42**	0.15
Light	**−0.29**	0.07	**−0.45**	0.07	**−0.54**	0.11
Moderate	**0.30**	0.06	**−0.38**	0.06	0.18	0.11
Vigorous	**0.32**	0.03	−0.03	0.02	−0.06	0.04
Moderate–vigorous	**0.62**	0.06	**−0.41**	0.06	0.12	0.11
Personal care	**0.06**	0.02	**−0.06**	0.02	0.02	0.02
Household	**−0.29**	0.06	0.01	0.06	**−1.68**	0.07
Leisure	**1.14**	0.04	**−0.24**	0.04	**−0.63**	0.05
Work	**−0.37**	0.05	**0.49**	0.08	**2.56**	0.13
Transportation	−0.01	0.01	**−0.05**	0.01	**0.03**	0.01
Shop/errands	**−0.07**	0.03	0.00	0.03	**−0.49**	0.03
Other	**−0.05**	0.02	**−0.05**	0.02	**−0.08**	0.02
Exercise	**1.33**	0.03	−0.05	0.03	**−0.28**	0.03
Sedentary time (hours/day)						
Total sedentary time	**−0.37**	0.09	**0.86**	0.08	**1.32**	0.15
Personal care	−0.01	0.03	0.02	0.03	**−0.16**	0.04
Household	**−0.06**	0.02	−0.01	0.02	**−0.29**	0.03
Leisure	0.07	0.08	**2.00**	0.07	**−2.11**	0.09
Work	−0.06	0.07	**−0.55**	0.07	**4.59**	0.14
Transportation	**−0.16**	0.04	**−0.40**	0.04	**−0.19**	0.05
Shop/errands	**−0.03**	0.01	−0.01	0.01	**−0.08**	0.01
Other	**−0.09**	0.03	**−0.20**	0.03	**−0.28**	0.04
TV	−0.03	0.05	**2.90**	0.05	**−0.22**	0.04

Note: Boldface indicates statistical significance (p<0.05).

[a]Mixed models: adjusted for age, sex, day of week, and season.

iDATA, Interactive Diet and Activity Tracking in AARP.

Table 3.

Difference in Physical Activity Energy Expenditure (MET-Hours/Day) by Day Type, iDATA Study, 2012–2013

	Difference in MET-hours/day by type of day[a]					
	Exercise (any)		TV (2+ hours/day)		Work (4+ hours/day)	
PAEE (MET-hours/day)	**β**	**SE**	**β**	**SE**	**β**	**SE**
Total PAEE	**2.83**	0.27	**−2.43**	0.26	−0.72	0.50
Light	**−0.65**	0.16	**−0.98**	0.15	**−0.87**	0.25
Moderate	**1.30**	0.23	**−1.39**	0.22	0.51	0.41
Vigorous	**2.25**	0.17	−0.22	0.14	−0.38	0.26
Moderate–vigorous	**3.51**	0.25	**−1.56**	0.25	0.14	0.46
Personal care	**0.11**	0.03	**−0.13**	0.03	0.04	0.04
Household	**−1.09**	0.20	−0.09	0.20	**−5.20**	0.24
Leisure	**5.64**	0.18	**−0.57**	0.15	**−1.97**	0.18
Work	**−1.12**	0.17	**−1.16**	0.17	**8.08**	0.46
Transportation	−0.03	0.03	**−0.15**	0.03	**0.10**	0.04
Shop/errands	**−0.17**	0.06	−0.01	0.06	**−1.12**	0.08
Other	**−0.23**	0.08	**−0.36**	0.08	**−0.54**	0.10
Exercise	**5.98**	0.10	−0.20	0.13	**−1.19**	0.16

Note: Boldface indicates statistical significance ($p<0.05$).

[a]Mixed models: adjusted for age, sex, day of week, and season.

iDATA, Interactive Diet and Activity Tracking in AARP; PAEE, physical activity energy expenditure.