Different Associations of Routine Work Time with Exercise Behavior and Objectively Measured Physical Activity among Middle-Aged and Older Adults: A Daily and Longitudinal Analysis

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Abstract

This study examined whether routine work time was associated with exercise time, moderate-to-vigorous physical activity (MVPA), and step counts (SC) among middle-aged and older adults. A seven-day diary survey was conducted with 158 adults, and 138 participated in the one-year follow-up survey for measuring routine work time and exercise time. An accelerometer was used to measure MVPA and SC, and a questionnaire assessed perceived barriers and self-efficacy. Daily analyses revealed that while longer routine work time was associated with shorter exercise time after adjusting for perceived exercise barriers and exercise self-efficacy, it was associated with higher amounts of MVPA and SC. Longitudinal analysis showed that increased routine work time was associated with decreased exercise time and increased MVPA and SC. Changes in perceived barriers and self-efficacy did not mediate these associations. Actual lack of time would inhibit exercise behavior independently of perceived barriers and self-efficacy but elevates MVPA and SC.

Keywords: exercise, healthy aging, leisure activities, life change events, motivation, time factors

Different Associations of Routine Work Time with Exercise Behavior and Objectively Measured Physical Activity among Middle-Aged and Older Adults: A Daily and Longitudinal Analysis

The present study addressed the question of whether time-related problems such as busyness and lack of time were actual barriers to engaging in exercise behaviors and physical activity. Physical inactivity increases the risk of major noncommunicable diseases (Kyu et al., 2016). Current guidelines for adults recommend at least 150 to 300 minutes per week of moderate-intensity physical activity, 75 to 150 minutes per week of vigorous-intensity physical activity, or an equivalent combination of the two (U.S. Department of Health and Human Services, 2018). Any bouts of physical activity can accumulate towards the total amount of time spent (U.S. Department of Health and Human Services, 2018). The U.S. Department of Health and Human Services (2018) also describes that step counts are useful for setting individual goals for moderate-to-vigorous physical activity and monitoring daily levels of activity. However, 27.5% of adults were physically inactive in 2016, and the prevalence of physical inactivity has not significantly decreased since 2001 (Guthold, Stevens, Riley, & Bull, 2018). Thus, promotion of physical activity at the general population level is needed (Reis et al., 2016).

Exercise is a traditional and common way of accumulating physical activity. Exercise is conceptualized as physical activity that is planned, structured, repetitive, and designed to promote physical fitness and health (Physical Activity Guidelines Advisory Committee, 2018). The major component of physical activity performed during leisure time is exercise (Physical Activity Guidelines Advisory Committee, 2018). Numerous exercise forms, such as brisk walking, jogging, and strength training, equate to moderate-to-vigorous intensity (Ainsworth et al., 2011). It has been considered that one common barrier for people to engage in exercise is a time-related problem, such as busyness and lack of time. Many scales

measuring perceived barriers to exercise (Ishii et al., 2009a; Marcus, Rakowski, & Rossi, 1992; Sechrist, Walker, & Pender, 1987) and self-efficacy for maintaining exercise (Marcus, Selby, Niaura, & Rossi, 1992; Oka, 2003; Resnick & Jenkins, 2000) have contained items addressing time-related factors. Questionnaire surveys have also revealed that perceived lack of time and busyness are major barriers to exercise (Bautista, Reininger, Gay, Barroso, & McCormick, 2011; Ishii et al., 2009b; Japan Sports Agency, Ministry of Education, Culture, Sports, Science, and Technology, 2018). Qualitative studies have also shown time-related problems as perceived barriers to exercise (Boehm et al., 2013; Korkiakangas et al., 2011; Tulloch et al., 2013).

Although lack of time and busyness are well-known perceived barriers to exercise, the influences of actual lack of time on exercise behavior have not been established. Instead of measuring actual time spent in daily routine work (e.g., daily hours doing paid work and household chores) or actual free time, many previous studies have only measured one's perceptions of subjective busyness or time limitations. In an occupational context, the associations of time in paid work and exercise have been examined. A review article concluded that longer hours in paid work would inhibit leisure time physical activity, which closely overlaps with exercise (Kirk & Rhodes, 2011). However, Angrave, Charlwood, and Wooden (2015) argued that the association between working hours and leisure time physical activity in this review (Kirk & Rhodes, 2011) was inconclusive because (a) many of the previous studies included in the review did not report any significant associations, (b) the significant associations reported in previous studies were often small or observed only in sub-groups, and (c) most of the studies analyzed cross-sectional data. Angrave et al. (2015) analyzed the data from a longitudinal survey conducted annually for five years and revealed that long working hours were not longitudinally related to exercise behavior. One potential reason for the inconsistent findings in occupational studies is that researchers have not

measured time engaged in other routine behaviors such as household chores, commuting, and caregiving. Along with paid work, such behaviors are unignorable routines for many adults. For example, the average Japanese adult spends 4 hours and 14 minutes on paid work, 41 minutes on commuting, 19 minutes on caregiving, and 1 hour and 43 minutes on other household chores on a typical weekday (Statistics Bureau, Japanese Ministry of Internal Affairs and Communications, 2017a). Nonetheless, few studies have examined the total effects of paid and unpaid work on exercise behaviors.

To better understand the relationship between routine work and exercise behavior, it is beneficial to identify the potential mediators in these relationships. Psychosocial factors, such as perceived barriers and self-efficacy, might mediate such relationships. As time-related factors are included in the scales for perceived barriers and self-efficacy (Ishii et al., 2009; Marcus, Rakowski, et al., 1992; Marcus, Selby et al., 1992; Resnick & Jenkins, 2000; Sechrist et al., 1987), longer time spent in daily routine work might strengthen one’s perception of barriers to exercise and weaken one’s self-efficacy to maintain it. In turn, more perceived barriers and weakened self-efficacy might inhibit exercise behavior. The identification of mediators would also contribute to explaining the inconsistencies of working hours and exercise behavior in previous studies.

Furthermore, longer routine work time might influence total amounts of moderate-to-vigorous physical activity and step counts differently than exercise behavior. More time spent in certain types of routine work can provide more opportunities for accumulating moderate-to-vigorous physical activity and step counts in occupational and household settings. Thus, even if longer routine work time is the actual barrier to exercise, it would not necessarily decrease total amounts of moderate-to-vigorous physical activity or step counts. Exercise is usually performed in leisure settings and is just one pathway to accumulating moderate-to-vigorous physical activity and step counts. People can accumulate total amounts through

other pathways such as occupational and household tasks. Various activities in occupational and household chores are equal to moderate-to-vigorous intensity levels (Ainsworth et al., 2011). In particular, occupational studies have consistently shown that blue-collar/manual workers have higher levels of total physical activity (Kirk & Rhodes, 2011). As well as leisure time, occupations and households are recognized as major domains that contribute to accumulate physical activity (Salmon, Owen, Bauman, Schmitz, & Booth, 2000). If routine work involves moderate-to-vigorous intensities, the negative effects of routine work on exercise behavior would be weakened or offset in focusing on the total amount of moderate-to-vigorous physical activity and step counts.

The purposes of the present study were to examine (a) whether longer routine work time was associated with shorter exercise time, (b) whether perceived exercise barriers and exercise self-efficacy mediated the association between routine work time and exercise time, and (c) whether the associations of routine work time with moderate-to-vigorous physical activity and step counts were weaker or null compared with its association with exercise time among middle-aged and older adults. Both moderate-to-vigorous physical activity and step counts were equally regarded as indices of individuals' physical activity level. The present study addressed these research questions with both daily and longitudinal analyses. It is reasonable to consider that time spent on routine work is not stable and varies at both the daily and yearly levels. At the daily level, time spent on paid work, commuting, and household chores is considerably different on weekdays versus weekends (Statistics Bureau, Japanese Ministry of Internal Affairs and Communications, 2017). The daily analyses in the present study investigated whether daily variations in routine work time explained daily variations in exercise time, moderate-to-vigorous physical activity, and step counts within each individual. At the yearly level, middle-aged and older adults occasionally experience dramatic changes in occupational or family status (e.g., promotion or demotion in

employment, retirement, re-employment, independence and marriage of children, and birth of grandchildren). Such experiences would lead to changes in one's usual routine work time. The present study longitudinally analyzed whether one-year changes in one's usual routine work time accompanied one-year changes in exercise and physical activity variables.

Method

Participants and Procedures

The present study was conducted as part of a larger survey. We have written several articles in addition to this one using the survey data covering the associations of social support and exercise behavior (Xxxxxx, Xxxxxxx, & Xxxxx, 2017), the correlation of physical activity between husbands and wives (Xxxxxx, Xxxxxxx, & Xxxxx, 2018), the associations of out-of-home time with physical activity (Xxxxxx, Xxxxxxx, & Xxxxx, 2019), and the associations of exercise behavior with mental health (Xxxxxx, Xxxxxxx, & Xxxxx, in press). We have described the details of the participants and procedures in our prior articles. The present study targeted middle-aged and older adults living in four areas located in Xxxxx (deleted for blinded review process) Prefecture, Japan: Xxxx Ward of Xxxx City, Xxxxxxxx City, Xxxx City, and Xxxxx City. From the official basic resident registers of the four areas, the present study randomly selected 540 men aged 59, 64, or 69 and their wives (135 men and women per area) on April 1, 2016, which was the first day of Japan's financial year. The registers contain basic information such as residents' sex and date of birth. From the basic information, we identified eligible individuals for the present study. The rationale for targeting this age group was that a considerable number of men would change their working status or retire from work on March 31st, 2017, the last day of Japan's financial year 2016. In Japanese employment systems, most employees change or retire from their work on the last day of a financial year when they reach 60, 65, or 70 years old. This survey recruited couples because the survey had multiple purposes: we examined whether physical activity levels were

correlated between husbands and wives, and this was reported in another paper (Xxxxxx, Xxxxxx, & Xxxxx, 2018).

The present study sent the recruitment document to 540 couples inviting them to participate in our survey that combined the questionnaire survey, accelerometer, and diary survey for seven consecutive days. Among them, 158 individuals (79 couples) actually participated in the entire survey. The present study provided book coupons worth 5000 Japanese yen as incentives to each couple. The present study treated this survey as the baseline measure. After one year, the present study asked 158 individuals to participate in a follow-up survey, and 138 individuals (69 couples) actually participated. The content of the one-year follow-up survey was the same as in the baseline survey.

Informed consent was obtained from all participants for this project. The present study received prior approvals (baseline survey, No. 209; one-year follow-up survey, No. 286) from the Ethical Committee of the Graduate School of Xxxxx Xxxxxxxxxxx xxx Xxxxxxxx, Xxxxx University (deleted for blinded review process). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Measures

Routine work time. Routine work time was measured by a diary survey for seven consecutive days. Before going to bed each day, the individuals were asked to record the time they spent on paid work, commuting to and from a workplace, and household chores in the diary. If they engaged in paid work, they were asked to answer whether their work was mainly sedentary (sitting) or active (standing, walking, or physical labor). The household chore time was defined as the total time spent on six activities: cooking meals, washing dishes, cleaning rooms, laundry, caring for older adults, and caring for young children. Time

spent in sedentary and active paid work, commuting, and household chores was combined as routine work time.

Exercise time. Self-reported methods are usually necessary to obtain data on exercise behavior in free living settings because accelerometers cannot validly record these data. As with daily routine work time, the diary survey was employed as the method of measurement. The participants were asked to record their exercise time every day. Walking for exercise, calisthenics, and sports were listed as examples of exercise. Walking for exercise and calisthenics are the first and second most common exercise types in the Japanese population aged 60 to 69 years (Japan Sports Agency, 2018). The Physical Activity Guidelines published in the United States also refer to walking and some calisthenics as examples of exercise (U.S. Department of Health and Human Services, 2018). According to the Compendium of Physical Activities (Ainsworth et al., 2011), both walking for pleasure and general calisthenics are moderate-intensity activities. Additionally, we also listed sport as an example of intense and competitive exercises.

Moderate-to-vigorous physical activity and step counts. The present study measured step counts and moderate-to-vigorous physical activity using a triaxial accelerometer (HJA-750C, Active Style Pro, Omron Healthcare Co., Ltd., Kyoto, Japan). Although walking cadence (step/minute) has been proposed as a proxy-indicator of the intensity of physical activities (Tudor-Locke et al., 2018), this accelerometer cannot measure walking cadence. The present study defined moderate-to-vigorous physical activity as all activities involving ≥ 3 metabolic equivalents. The algorithm of the accelerometer (HJA-750C) was the same as that of the older model (HJA-350IT). The validity of the HJA-350IT for estimating energy expenditure was confirmed (Murakami et al., 2016; Ohkawara et al., 2011). Furthermore, along with locomotive activities such as walking and running, the accelerometer can estimate the intensities of household activities such as laundry, moving a

small load, and vacuuming through a validated algorithm (Oshima et al., 2010). Examining 12 types of accelerometers simultaneously, Murakami et al. (2016) reported that although all of the accelerometers underestimated total energy expenditure on free-living days compared with the doubly labeled water method, underestimation was the lowest in the HJA-350IT. While this accelerometer has two options for epoch length, 10 seconds or 1 minute, the present study chose 10 seconds because it can be expected that a shorter epoch length estimates moderate-to-vigorous physical activity time more accurately than the longer epoch length.

The present study conducted the accelerometer survey for the same seven consecutive days as the diary survey. The participants were asked to wear the accelerometer on their waists all day except when bathing and sleeping, and to live as normal. The monitor results were blinded, and individuals could not check their records themselves.

An eligible day was defined as a day when the accelerometer was worn 10 to 20 hours. We defined non-wearing time as any period of at least 60 minutes in which the accelerometer data were not recorded, and calculated wearing time by subtracting non-wearing time from 24 hours. Previous studies have commonly employed the inclusion criteria of wearing time as ≥ 10 hours per day (Gorman et al., 2014). Although individuals were asked to take off the accelerometer when sleeping, the data indicated that a few individuals wore it when sleeping. Thus, days of wearing it ≥ 20 hours were also excluded. Following the criteria used in other studies (Gorman et al., 2014), data from participants who had at least 4 eligible days were included in the analyses.

Perceived exercise barriers and exercise self-efficacy. A sub-scale of a Japanese scale for perceived benefits and barriers to exercise (Ishii et al., 2009a) was employed. This scale consists of 20 items: 10 for benefits and 10 for barriers. Respondents answered each item on a five-point Likert scale. The scores of the 10 items for the barriers were summed

(range: 10 to 50). Higher scores represented higher perceived barrier. The internal consistency (Spearman-Brown reliability coefficient = 0.48 to 0.82) and test–retest reliability (r = 0.51 to 0.79) of this scale are acceptable (Ishii et al., 2009a). Ishii et al. (2009a) also confirmed the construct and criterion-related validity of this scale.

A self-efficacy for exercise scale (Oka, 2003) assessed the confidence of participants who engaged in exercise when faced with four common barriers on a five-point Likert scale. The score of each item was summed. Higher scores represented higher self-efficacy (range: 4 to 20). The two-week test-retest reliability (r = 0.78) and internal consistency (Cronbach's α = 0.84) of this scale is good (Oka, 2003). Oka (2003) also confirmed its construct validity.

Basic factors. Gender, age, and education (junior high/high school, beyond high school) were measured as basic factors by the questionnaire survey.

Analyses

Daily analyses. Multilevel models were employed for the daily associations of routine work time with exercise time, moderate-to-vigorous physical activity, and step counts at baseline by using the *mixed* command of Stata version 14 (StataCorp LLC, College Station, Texas, the United States). Maximum likelihood estimation was used to fit the model.

With exercise time as the dependent variable, the present study developed two models with 153 individuals who had no missing data at baseline (an average of 6.56 days per individual). The independent variables in the first model were daily routine work time (Level 1, within-person level), overall routine work time, gender, and educational background (Level 2, between-person level). For the second model, the present study added perceived exercise barriers and exercise self-efficacy as the independent variables at Level 2. In addition to the variance of slope for daily routine work time and the intercept for individuals, the variance of intercept for couples (Level 3, couples level) was included as a random effect because the present study recruited spousal couples.

Setting moderate-to-vigorous physical activity and step counts as the dependent variables, the present study analyzed two models. The first model analyzed routine work time directly. In the second model, routine work time was separated into four components: household time, sedentary work time, active work time, and commuting time. The baseline data of 152 individuals (an average of 6.57 days per individual) and 149 individuals (an average of 6.44 days per individual) were analyzed for the first and second models, respectively. Regarding the rationale for examining two models for each dependent variable, it can be argued that the degree to which moderate-to-vigorous intensity levels are involved are different among these four components, and thus, they would differently influence on moderate-to-vigorous physical activity and step counts. The independent variables were daily accelerometer wearing time, daily routine work time or its 4 components, daily exercise time (Level 1, within-person level), overall accelerometer wearing time, overall routine work time or its 4 components, overall exercise time, gender, educational background, and age (Level 2, between-person level). The variances of the slopes for daily accelerometer wearing time, daily routine work time or its four components, and daily exercise time and the variances of intercept for individuals and couples were treated as random effects.

All continuous variables at Level 2 were mean-centered. Gender (men = 0, female = 1) and education (junior high/high school = 0, beyond high school = 1) were treated as dummy variables. Similar to previous studies (Conroy et al., 2013; Maher & Conroy, 2017), the present study calculated overall time variables as each person's mean time across seven days and daily time variables as the differences in each day's time from each person's overall time.

Longitudinal analyses. For longitudinal associations among one-year changes in average amounts of routine work time, exercise time, moderate-to-vigorous physical activity, and step counts, path analyses were conducted for 121 individuals without missing data in the

baseline and follow-up surveys using the AMOS (version 21.0; IBM Japan, Ltd., Tokyo, Japan) software package. The present study examined two models; the first model analyzed routine work time directly, and the second model separated routine work time into four components. The goodness of fit index (GFI), comparative fit index (CFI), and root mean square error of approximation (RMSEA) were used as indices of model fit.

Similar to previous studies (Cavallo et al., 2014; Gunnell, Crocker, Mack, Wilson, & Zumbo, 2014), residualized change scores were examined as the one-year change variables in the path analyses. For each variable, the present study first obtained the predicted value of the one-year follow up by regressing the baseline value, and the residualized change score was then calculated by subtracting the predicted value from the actual value. The path analysis specified (a) a path from perceived exercise barriers to exercise self-efficacy; (b) paths from perceived exercise barriers and exercise self-efficacy to exercise time; (c) paths from exercise time to moderate-to-vigorous physical activity and step counts; (d) paths from routine work time to perceived exercise barriers, exercise self-efficacy, exercise time, moderate-to-vigorous physical activity, and step counts; and (e) the paths from accelerometer wearing time to moderate-to-vigorous physical activity and step counts. For the second model, the correlations among the four components of routine work time were also included.

Results

Baseline Respondent Characteristics

Table 1 shows the characteristics of the respondents. Among them, 106 (67.1%: 61 men and 45 women) were current workers, and 52 (32.9%: 18 men and 34 women) were non-workers at baseline. As shown in Table 1, the average step count per day was 6,671.3, and the average moderate-to-vigorous physical activity time per day was 1 hour and 33 minutes. Based on t-tests and chi-squared tests, there were no statistically significant differences in the baseline data between those with and those without missing data for the daily and

longitudinal analyses, respectively (Supplementary Table 1).

The results of Pearson's correlation coefficients are indicated in Supplementary Table 2. Average exercise time was negatively correlated with average routine work time and average active work time. Average step counts was positively correlated with average routine work time, average active work time, and average commuting time. Average moderate-to-vigorous physical activity time was positively correlated with average routine work time and average active work time. The scatter plot for the relationship between average step counts per day and moderate-to-vigorous physical activity time per day is shown in Supplementary Figure 1. The value of R^2 for this relationship was 0.534.

Daily Associations of Routine Work Time with Exercise Time

Table 2 represents the results of the fixed effects in the multilevel models for exercise time at baseline. The random effects are shown in Supplementary Table 3. Longer routine work time was associated with shorter exercise time at both the within- and between-person levels (Model 1). The associations of overall and daily routine work time with exercise time were still significant after adjusting for perceived exercise barriers and exercise self-efficacy (Model 2).

Daily Associations of Routine Work Time with Moderate-to-Vigorous Physical Activity and Step Counts

The results of the fixed effects in the multilevel models for moderate-to-vigorous physical activity are shown in Table 3. The random effects are indicated in Supplementary Table 4. At both the within- and between-person levels, longer routine work time was associated with longer moderate-to-vigorous physical activity time (Model 1). After separating routine work time into four components (Model 2), longer active work time was associated with longer moderate-to-vigorous physical activity time at both levels.

Table 4 shows the results of the fixed effects in the multilevel models for step counts.

Supplementary Table 5 indicates their random effects. Similar to moderate-to-vigorous physical activity, longer routine work time were associated with higher step counts at both the within- and between-personal levels. Of the four components of routine work time, active and sedentary work time were both associated with higher step counts at both levels.

Longitudinal Associations of Routine Work Time with Exercise Time, Moderate-to-Vigorous Physical Activity, and Step Counts

Figure 1 represents the path analysis for the direct and indirect associations of one-year changes in average routine work time per day with one-year changes in average exercise time, moderate-to-vigorous physical activity time, and step counts per day. The indices of model fit were GFI = 0.967, CFI = 0.953, and RMSEA = 0.085. While increased routine work time was associated with decreased exercise time, it was also associated with increased moderate-to-vigorous physical activity time and step counts. Significant associations of perceived exercise barriers and exercise self-efficacy with routine work time and exercise time were not revealed.

Figure 2 represents the path analysis for separating one-year changes in routine work time into four components. The indices of model fit were GFI = 0.971, CFI = 0.960, and RMSEA = 0.079. While increased household time was associated with decreased exercise time, increased household time was associated with increased moderate-to-vigorous physical activity. Increased active work time was associated with increased exercise self-efficacy, moderate-to-vigorous physical activity, and step counts. Sedentary work time and commuting time were not significantly associated with exercise time, moderate-to-vigorous physical activity time, or step counts. Associations of perceived exercise barriers and exercise self-efficacy with exercise time were not significant.

Discussion

The present study revealed that longer routine work time was associated with shorter

exercise time at both within- and between-person levels, and that increase in routine work time was associated with decreased exercise time even one year later. These findings indicate that actual lack of time would be a barrier to exercise among middle-aged and older adults. While the influences of time-related factors on exercise behavior were well examined (Bautista et al., 2011; Boehm et al., 2013; Ishii et al., 2009b; Japan Sports Agency, Ministry of Education, Culture, Sports, Science, and Technology, 2018; Korkiakangas et al., 2011; Tulloch et al., 2013), the influences of actual lack of time have not been sufficiently investigated. To justify whether time-related factors are just excuses or real problems prohibiting the engagement in exercise, the investigation of actual lack of time is essential. To the best of our knowledge, only one cross-sectional study (Reichert et al., 2007) showed that actual longer routine work time was negatively associated with leisure time physical activity, but this study (Reichert et al., 2007) did not employ a multilevel approach. Thus, the present study strengthens the finding of this previous study (Reichert et al., 2007) by examining both daily and longitudinal associations.

In the daily analyses, routine work time was still significantly associated with exercise time after adjusted for perceived exercise barriers and exercise self-efficacy. The longitudinal path analysis revealed that increased routine work time was not significantly associated with increased perceived exercise barriers or decreased exercise self-efficacy, and it also showed that changes in perceived exercise barriers and exercise self-efficacy were not associated with changes in exercise time. These results indicate that the influences of routine work on exercise behavior would be independent of perceived barriers and self-efficacy. Furthermore, actual lack of time would not be a major source of higher perceived barriers and lower self-efficacy toward exercise. Although both factors are well-known psychological correlates of exercise and physical activity, a systematic review (Rhodes & Quinlan, 2014) argued that the longitudinal associations of changes in these factors with changes in physical activity are still

inconclusive because a considerable number of null results have been reported. Instead of the mediation of perceived barriers and self-efficacy, other pathways might exist from daily routine work to exercise behavior. According to a systematic review (Rebar et al., 2016), one potential pathway might be non-conscious processes (e.g., habits, automatic associations). However, due to the lack of previous studies, further large-scale longitudinal examinations are warranted to examine the associations among routine work time, perceived barriers, self-efficacy, and exercise behavior.

Both daily and longitudinal analyses revealed that longer routine work time was associated with greater amounts of moderate-to-vigorous physical activity and step counts. Dividing routine work time into four components showed that, while longer active work time was consistently associated with greater amounts of moderate-to-vigorous physical activity and step counts in both daily and longitudinal analyses, clear and robust associations of household, sedentary work, and commuting time were not revealed in these analyses. These findings indicate that longer routine work time, especially longer active working time, would elevate moderate-to-vigorous physical activity levels and accumulate step counts among middle-aged and older adults. As it is well-known that blue-collar/manual occupational categories are associated with higher levels of total physical activity (Kirk & Rhodes, 2011), the negative influence of longer routine work on exercise behavior would be offset if it is active in nature. The potential reason for the unclear results regarding the associations of household time with physical activity variables is that most of the individuals in the present study might engage in household chores with only light, not moderate, effort. The absence of assessment of the commuting styles, such as private car or walking/cycling, might cause unclear associations of commuting time with moderate-to-vigorous physical activity and step counts.

However, it should be noted that longer time spent in household work, sedentary

work, and commuting were not significantly associated with lower amounts of moderate-to-vigorous physical activity and step counts in the daily analyses. Further, increases in these times were not significantly associated with decreases in the total amount of moderate-to-vigorous physical activity and step counts in the longitudinal analyses. These results indicate that they would not inhibit the accumulation of moderate-to-vigorous physical activity and step counts. Epidemiological studies have shown that objectively measured physical activity levels (Evenson, Wen, & Herring, 2016; Loprinzi, & Joyner, 2016; Yates et al., 2014) have desirable influences on health outcomes. Current physical activity guidelines (Physical Activity Guidelines Advisory Committee, 2018; U.S. Department of Health and Human Services, 2018) emphasize that accumulating physical activity of any type, in any location, and for any purpose is important for public health, rather than narrowing the recommendations to exercise. Thus, according to the present study results, the negative influences of longer routine work time on exercise behavior might not be a serious public health matter because longer routine work time would not be a barrier to accumulate total amounts of moderate-to-vigorous physical activity and step counts.

In the present study, the average step counts per day at baseline (6,671.3 steps/day) was comparable to a nationally representative Japanese dataset (7,162 steps/day for men aged 60 to 69 years and 6,559 steps/day for women aged 60 to 69 years; Inoue et al., 2011). The participants in the present study were not extremely active by such standards. However, the average moderate-to-vigorous physical activity levels at baseline (93.1 minutes/day) were remarkably higher than the current physical activity guidelines. While the value of R^2 for the relationship between average step counts and moderate-to-vigorous physical activity in the present study was 0.53, a previous study (Tudor-Locke, Johnson, & Katzmarzyk, 2011) using ActiGraph, a well-known accelerometer in Western countries, reported the value of R^2 for the relationship between average step counts and moderat physical activity to be 0.60 among

older adults. Thus, the degree of concordance between step counts and moderate-to-vigorous physical activity measured by the Active Style Pro, the accelerometer used in the present study, is comparable to that measured by ActiGraph. The higher level of moderate-to-vigorous physical activity might be largely derived from two characteristics of the Active Style Pro. First, the measured time spent on moderate-to-vigorous physical activity notably varies according to epoch length. Nakata, Ohkawara, Oshima, and Tanaka (2012) reported that while step counts per days are equal regardless of epoch length (approximately 6,200 steps/day in both epochs), the moderate-to-vigorous physical activity time obtained from 10-second epochs (92.3 minutes/day) is notably longer than that obtained from 1-minute epochs (65.0 minutes/day) among middle-aged adults. Second, the accelerometer estimates the intensities of household activities with a validated algorithm (Oshima et al., 2010). Nakata et al. (2012) showed that among the total time (92.3 minutes/day) spent on moderate-to-vigorous physical activity measured by 10-second epochs, 33.9% (31.3 minutes/day) was classified as locomotive activity and 66.1% (61.0 minutes/day) was classified as household activity. Tanaka and Tanaka (2013) reported same trends regarding these two characteristics.

The examinations of both daily and longitudinal data are the strengths of the present study. Concordances in the daily and longitudinal examinations emphasize the robustness of the findings. The use of the accelerometer and the diary method are other strengths. Their use can provide more accurate data than that obtained through traditional questionnaire surveys. However, the present study had several limitations. First, the sample size was small. Second, although the ratio of current workers in the present study (78.2% of men and 57.0% of women) is comparable to that for the general Japanese population aged 20 to 69 years (76.4% of men and 60.2% of women; Statistics Bureau, Japanese Ministry of Internal Affairs and Communications, 2017b), a sampling bias may exist. Third, the generalizability of the findings to other populations, such as younger age groups, is unclear. Fourth, the

measurement method of daily exercise time was not standard and established, and its psychometric properties are unknown. Fifth, for household chore time, the present study measured only six tasks and overlooked other important tasks, such as gardening and running errands. This could underestimate the total amounts of routine work time. Finally, although the mode of commuting could confound the association of routine work time with moderate-to-vigorous physical activity and step counts, the present study did not address this. Nonetheless, the present study contributes to a better understanding of the influences of actual lack of time on exercise and physical activity.

In conclusion, from daily and longitudinal analyses, the present study found that longer routine work time was associated with shorter exercise time independent of perceived exercise barriers and exercise self-efficacy. However, longer routine work time, especially longer active working time, was associated with greater amounts of moderate-to-vigorous physical activity and step counts in middle-aged and older adults. These findings indicate that actual lack of time would inhibit engagement in exercise behavior but would elevate moderate-to-vigorous physical activity and step counts among these age groups. As for the practical implications of the present study, the roles of routine work would differ, entirely depending on the target behavior of physical activity promotions. When the target behavior is focused on exercise, lack of actual time might be a considerable barrier, regardless of people’s perceptions about barriers and self-efficacy. However, current physical activity guidelines (U.S. Department of Health and Human Services, 2018) do not limit the target behavior to exercise; the target behavior includes all types of physical activity. In this case, a longer routine work might not be a serious problem because it would not inhibit the accumulation of total physical activity.

Ethical Approval: All procedures performed in studies involving human participants were in

accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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Figure captions

Figure 1. Path analysis for the associations of one-year changes in routine work time with one-year changes in perceived exercise barriers, exercise self-efficacy, exercise time, step counts, and moderate-to-vigorous physical activity. Solid and dashed lines represent significant and non-significant paths, respectively.

GFI = 0.967, CFI = 0.953, RMSEA = 0.085.

*$p<0.05$, **$p<0.01$, ***$p<0.001$

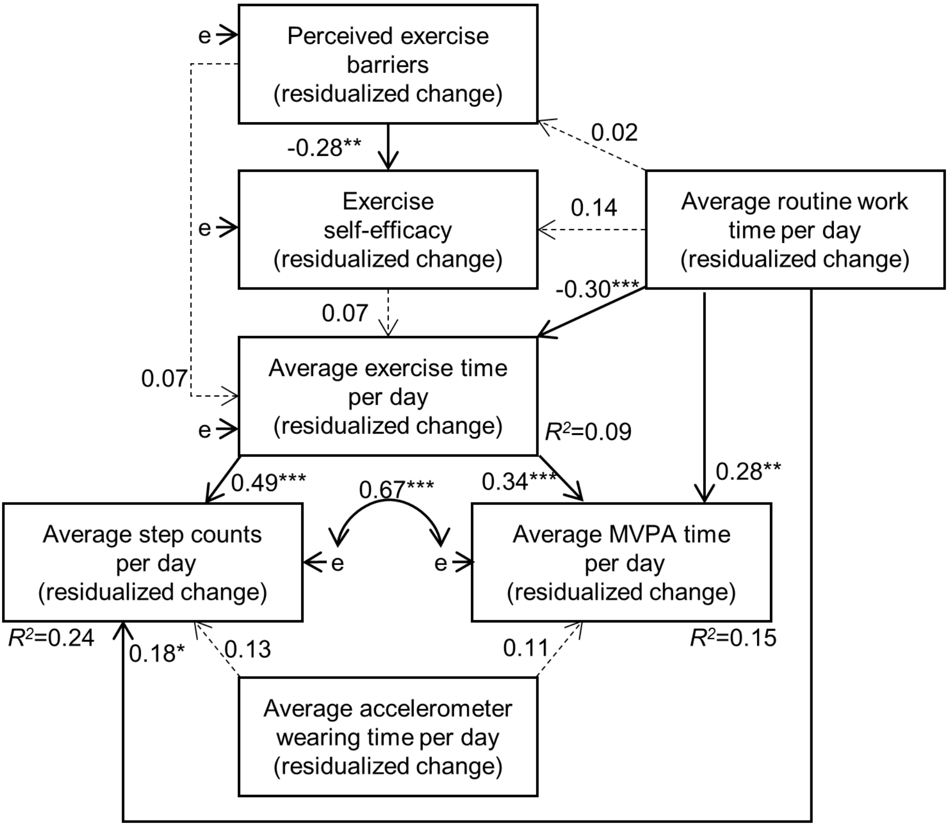
MVPA, moderate-to-vigorous physical activity

Figure 2. Path analysis for the associations of one-year changes in average household time, active and sedentary work time, and commuting time with one-year changes in perceived exercise barriers, exercise self-efficacy, exercise time, step counts, and moderate-to-vigorous physical activity. Solid and dashed lines represent significant and non-significant paths, respectively. Although the actual analysis examined the correlations among average household time, active and sedentary work time, and commuting time, these correlations are not shown in this figure for readability.

GFI = 0.971, CFI = 0.960, RMSEA = 0.079.

*$p<0.05$, **$p<0.01$, ***$p<0.001$

MVPA, moderate-to-vigorous physical activity



e
Perceived exercise barriers (residualized change)
-0.28**
0.02
e
Exercise self-efficacy (residualized change)
0.14
Average routine work time per day (residualized change)
-0.30***
0.07
0.07
Average exercise time per day (residualized change)
e
R2=0.09
0.49***
0.67***
0.34***
0.28**
Average step counts per day (residualized change)
e
e
Average MVPA time per day (residualized change)
R2=0.24
0.18*
0.13
0.11
R2=0.15
Average accelerometer wearing time per day (residualized change)

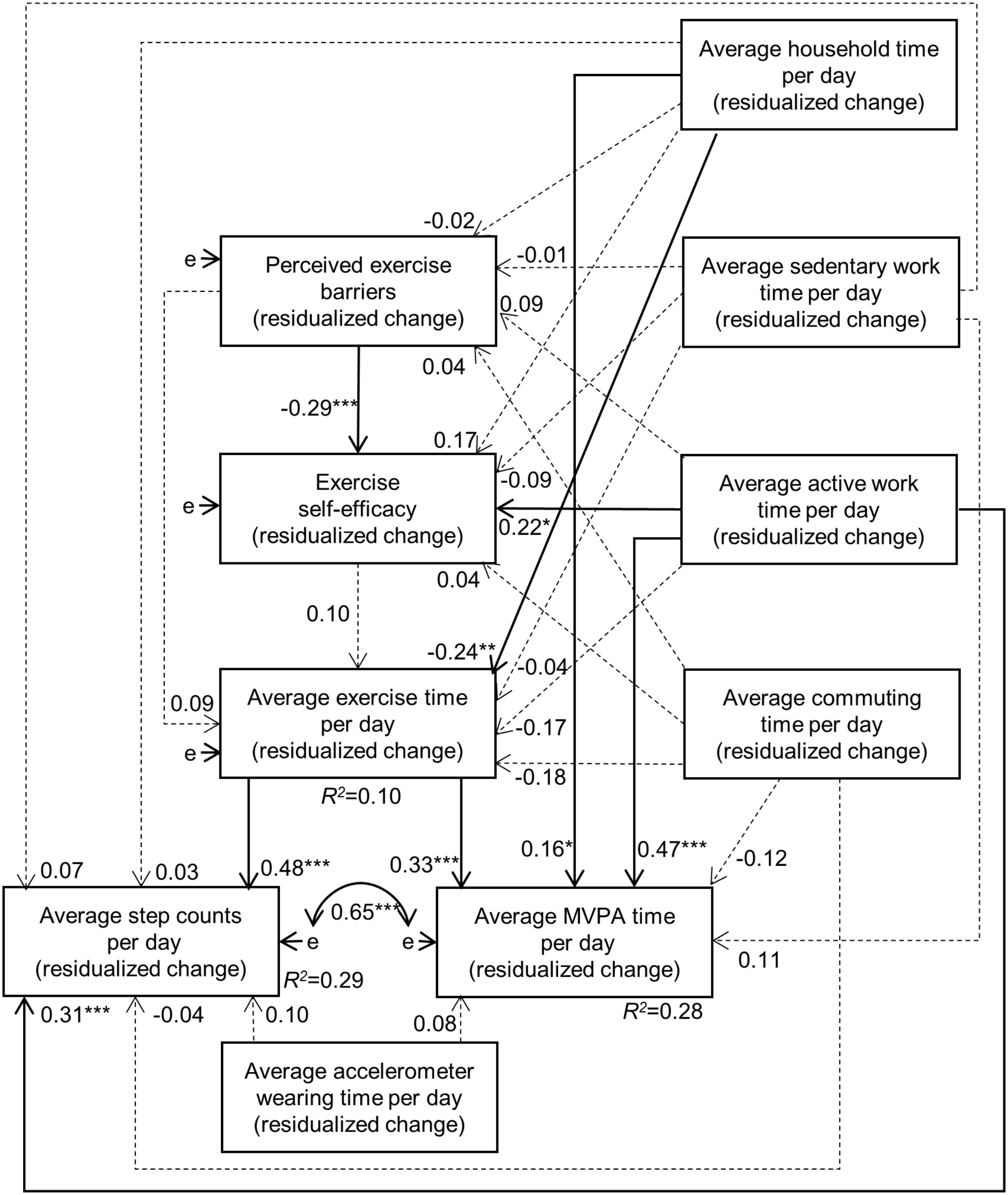

Average household time per day (residualized change)
Average sedentary work time per day (residualized change)
Average active work time per day (residualized change)
Average commuting time per day (residualized change)
Perceived exercise barriers (residualized change)
Exercise self-efficacy (residualized change)
Average exercise time per day (residualized change)
Average step counts per day (residualized change)
Average MVPA time per day (residualized change)
Average accelerometer wearing time per day (residualized change)
e
-0.02
-0.01
0.09
0.04
-0.29***
0.17
-0.09
0.22*
0.04
0.10
-0.24**
-0.04
0.09
-0.17
-0.18
R2=0.10
0.48***
0.33***
0.16*
0.47***
-0.12
0.07
0.03
0.65***
R2=0.29
0.11
R2=0.28
0.31***
-0.04
0.10
0.08

Table 1. *Characteristics of Participants at Baseline*

	n	Mean (SD) or %
Basic factors		
Gender (women)	158	50.0%
Education (beyond high school)	158	46.2%
Age (years)	158	63.2 (4.6)
Perceived barriers and self-efficacy		
Perceived exercise barriers	154	24.2 (6.5)
Exercise self-efficacy	157	11.5 (4.0)
Exercise and accelerometer variables		
Average accelerometer wearing time per day	153	14:43:27 (1:26:28)
Average step counts per day	153	6671.3 (3180.3)
Average MVPA time per day	153	1:33:08 (0:40:02)
Average exercise time per day	158	0:25:55 (0:30:09)
Routine work time variables		
Average routine work time per day	157	5:31:51 (3:04:31)
Average household time per day	158	2:14:08 (2:16:22)
Average sedentary work time per day	155	1:06:35 (2:01:06)
Average active work time per day	155	1:44:08 (2:25:42)
Average commuting time per day	157	0:19:53 (0:29:21)

Note. MVPA, moderate-to-vigorous physical activity.

Total sample size at baseline was 158.

Table 2. *Fixed Effects of Daily Analyses for Association of Routine Work Time and Exercise Time at Baseline (Multilevel Models)*

	Model 1		Model 2	
	Estimated (SE)	p value	Estimated (SE)	p value
Intercept	**2167.0 (472.2)**	**<0.001**	**1730.8 (429.4)**	**<0.001**
Within-person level				
Daily routine work time	**-0.038 (0.010)**	**<0.001**	**-0.037 (0.010)**	**<0.001**
Between-person level				
Gender	-504.5 (278.8)	0.070	-217.1 (251.6)	0.388
Educational background	285.7 (282.1)	0.311	303.1 (263.8)	0.250
Age	55.7 (33.8)	0.099	**64.4 (32.0)**	**0.044**
Overall routine work time	**-0.035 (0.013)**	**0.007**	**-0.041 (0.012)**	**0.001**
Perceived exercise barriers	—	—	24.3 (20.3)	0.232
Exercise self-efficacy	—	—	**192.4 (33.2)**	**<0.001**

Note. SE, standard error. Dependent variable was exercise time per day (1004 person-days). Gender (male = 0, female = 1) and education (junior high/high school = 0, beyond high school = 1) were treated as the dummy variables. Random effects were intercept for couple, intercept for person, and slope for daily routine work time. The results of the random effects in each model are shown in Supplementary Table 3.

Table 3. *Fixed Effects of Daily Analyses of the Association of Routine Work Time with Moderate-to-Vigorous Physical Activity at Baseline (Multilevel Models)*

	Model 1		Model 2	
	Estimated (SE)	p value	Estimated (SE)	p value
Intercept	**5276.2 (604.5)**	**<0.001**	**4149.9 (770.4)**	**<0.001**
Within-person level				
Daily accelerometer wearing time	**0.084 (0.009)**	**<0.001**	**0.077 (0.009)**	**<0.001**
Daily exercise time	**0.387 (0.038)**	**<0.001**	**0.384 (0.038)**	**<0.001**
Daily routine work time	**0.046 (0.008)**	**<0.001**	—	—
Daily household time	—	—	**0.047 (0.016)**	**0.002**
Daily sedentary work time	—	—	-0.007 (0.010)	0.490
Daily active work time	—	—	**0.081 (0.014)**	**<0.001**
Daily commuting time	—	—	0.026 (0.037)	0.492
Between-person level				
Gender	358.1 (353.2)	0.311	**956.3 (483.1)**	**0.048**
Educational background	-487.8 (363.8)	0.180	-90.5 (348.5)	0.795
Age	-55.3 (45.0)	0.219	-43.7 (42.9)	0.308
Overall accelerometer wearing time	**0.087 (0.036)**	**0.015**	**0.092 (0.034)**	**0.008**
Overall exercise time	**0.397 (0.103)**	**<0.001**	**0.474 (0.099)**	**<0.001**
Overall routine work time	**0.068 (0.018)**	**<0.001**	—	—
Overall household time	—	—	0.010 (0.030)	0.753
Overall sedentary work time	—	—	0.028 (0.027)	0.287
Overall active work time	—	—	**0.127 (0.023)**	**<0.001**
Overall commuting time	—	—	0.026 (0.100)	0.797

Note. SE, standard error. Dependent variable was time spent on moderate-to-vigorous

physical activity per day. Gender (male = 0, female = 1) and education (junior high/high school = 0, beyond high school = 1) were treated as the dummy variables. There were 998 valid person-days in Model 1 and 959 valid person-days in Model 2. The random effects in Model 1 were intercept for couples, intercept for individuals, slope for daily accelerometer wearing time, slope for daily exercise time, and slope for daily routine work time. The random effects in Model 2 were intercept for couples, intercept for individuals, slope for daily accelerometer wearing time, slope for daily exercise time, slope for daily household time, slope for daily sedentary work time, slope for daily active work time, and slope for daily commuting time. The results of the random effects in each model are shown in Supplementary Table 4.

Table 4. *Fixed Effects of Daily Analyses of the Association of Routine Work Time with Step Counts at Baseline (Multilevel Models)*

	Model 1		Model 2	
	Estimated (SE)	p value	Estimated (SE)	p value
Intercept	**7439.0 (765.1)**	**<0.001**	**5800.4 (957.3)**	**<0.001**
Within-person level				
Daily accelerometer wearing time	**0.099 (0.010)**	**<0.001**	**0.097 (0.010)**	**<0.001**
Daily exercise time	**0.677 (0.065)**	**<0.001**	**0.666 (0.065)**	**<0.001**
Daily routine work time	**0.068 (0.011)**	**<0.001**	—	—
Daily household time	—	—	0.019 (0.024)	0.434
Daily sedentary work time	—	—	**0.039 (0.016)**	**0.013**
Daily active work time	—	—	**0.101 (0.018)**	**<0.001**
Daily commuting time	—	—	0.051 (0.067)	0.447
Between-person level				
Gender	-492.1 (454.4)	0.279	495.5 (602.1)	0.410
Educational background	-85.3 (441.9)	0.847	186.9 (426.1)	0.661
Age	**-114.5 (53.4)**	**0.032**	-91.1 (51.8)	0.078
Overall accelerometer wearing time	**0.113 (0.043)**	**0.009**	**0.119 (0.042)**	**0.004**
Overall exercise time	**0.817 (0.128)**	**<0.001**	**0.858 (0.122)**	**<0.001**
Overall routine work time	**0.097 (0.022)**	**<0.001**	—	—
Overall household time	—	—	0.018 (0.037)	0.621
Overall sedentary work time	—	—	**0.066 (0.033)**	**0.042**
Overall active work time	—	—	**0.117 (0.028)**	**<0.001**
Overall commuting time	—	—	**0.321 (0.124)**	**0.010**

Note. SE, standard error. Dependent variable was step counts per day. Gender (male = 0,

female = 1) and education (junior high/high school = 0, beyond high school = 1) were treated as the dummy variables. There were 998 valid person-days in Model 1 and 959 valid person-days in Model 2. The random effects in Model 1 were intercept for couples, intercept for individuals, slope for daily accelerometer wearing time, slope for daily exercise time, and slope for daily routine work time. The random effects in Model 2 were intercept for couples, intercept for individuals, slope for daily accelerometer wearing time, slope for daily exercise time, slope for daily household time, slope for daily sedentary work time, slope for daily active work time, and slope for daily commuting time. The results of the random effects in each model are shown in Supplementary Table 5.

Supplementary Table 1. Comparison of baseline data between those with and those without missing data for daily and longitudinal analyses

	Missing data for daily analyses (n = 158)					Missing data for longitudinal analyses (n = 158)				
	With missing data (n = 12)		Without missing data (n = 146)			With missing data (n = 37)		Without missing data (n = 121)		
	n	M (SD) or %	n	M (SD) or %	p value	n	M (SD) or %	n	M (SD) or %	p value
Basic factors at baseline										
Gender (women)	12	58.3%	146	49.3%	0.548[a]	37	54.1%	121	48.8%	0.573[a]
Education (beyond high school)	12	33.3%	146	47.3%	0.352[a]	37	37.8%	121	48.8%	0.244[a]
Age (years)	12	64.2 (4.5)	146	63.1 (4.6)	0.436[b]	37	63.3 (4.1)	121	63.1 (4.7)	0.823[b]
Perceived barriers and self-efficacy at baseline										
Perceived exercise barriers	8	23.9 (4.6)	146	24.2 (6.6)	0.889[b]	33	23.7 (6.0)	121	24.3 (6.7)	0.604[b]
Exercise self-efficacy	11	10.9 (4.9)	146	11.5 (3.9)	0.626[b]	36	11.1 (3.9)	121	11.6 (4)	0.501[b]
Exercise and accelerometer variables at baseline										
Average accelerometer-wearing time per day	7	15:15:24 (01:38:13)	146	14:41:56 (01:25:56)	0.319[b]	32	14:43:46 (01:21:37)	121	14:43:22 (01:28:02)	0.981[b]
Average step counts per day	7	6516.9 (3318.9)	146	6678.8 (3185.2)	0.896[b]	32	6429.0 (2860.8)	121	6735.4 (3267.6)	0.629[b]
Average MVPA time per day	7	01:51:53 (00:38:52)	146	01:32:15 (00:40:00)	0.206[b]	32	01:36:46 (00:40:12)	121	01:32:11 (00:40:07)	0.566[b]
Average exercise time per day	12	00:18:45 (00:24:55)	146	00:26:31 (00:30:32)	0.393[b]	37	00:20:13 (00:20:15)	121	00:27:40 (00:32:27)	0.190[b]
Routine work-time variables at baseline										

Average routine work time per day	11	04:34:00 (03:49:00)	146	05:36:00 (03:00:00)	0.284[b]	36	05:00:00 (03:03:00)	121	05:41:00 (03:04:00)	0.252[b]
Average household time per day	12	01:31:29 (01:19:16)	146	02:17:38 (02:19:38)	0.261[b]	37	01:52:26 (01:36:56)	121	02:20:46 (02:26:01)	0.270[b]
Average sedentary work time per day	9	00:32:32 (01:28:23)	146	01:08:41 (02:02:45)	0.386[b]	34	00:48:04 (01:43:44)	121	01:11:47 (02:05:26)	0.314[b]
Average active work time per day	9	01:00:38 (01:25:29)	146	01:46:49 (02:28:23)	0.358[b]	34	01:38:05 (02:10:01)	121	01:45:51 (02:30:16)	0.785[b]
Average commuting time per day	11	00:16:45 (00:21:28)	146	00:20:07 (00:29:54)	0.715[b]	36	00:21:43 (00:36:00)	121	00:19:20 (00:27:13)	0.671[b]

[a]Chi-squared test

[b]t-test

Supplementary Table 2. *Pearson's Correlation Coefficients among Average Routine Work Time, Exercise Time, Accelerometer Variables, Psychosocial Factors, and Basic Factors at Baseline*

	Pearson's correlation coefficients												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Basic factors													
1. Gender (women)	—												
2. Education (beyond high school)	-0.04	—											
3. Age (years)	**-0.33*****	-0.13	—										
Perceived barriers and self-efficacy													
4. Perceived exercise barriers	0.02	**0.17***	-0.14	—									
5. Exercise self-efficacy	**-0.16***	-0.06	0.05	**-0.29*****	—								
Exercise and accelerometer variables													
6. Average accelerometer wearing time per day	**0.18***	0.03	-0.12	0.08	-0.11	—							
7. Average step counts per day	-0.01	0.09	-0.13	0.03	**0.28*****	**0.24****	—						
8. Average MVPA time per day	**0.16***	-0.04	-0.14	0.01	0.12	**0.24****	**0.73*****	—					

9. Average exercise time per day	**-0.24****	0.06	**0.25****	-0.08	**0.40*****	0.00	**0.35*****	0.15	—					
Routine work time variables														
10. Average routine work time per day	**0.26****	0.03	**-0.24****	0.11	0.01	0.10	**0.20***	**0.27****	**-0.29*****	—				
11. Average household time per day	**0.66*****	0.01	-0.11	-0.02	-0.12	**0.27****	-0.08	0.03	-0.12	**0.37*****	—			
12. Average sedentary work time per day	**-0.23****	**0.22****	**-0.17***	0.00	**0.19***	-0.07	0.12	-0.06	0.02	**0.37*****	**-0.21****	—		
13. Average active work time per day	-0.09	-0.15	-0.06	0.14	-0.05	-0.04	**0.18***	**0.32*****	**-0.26****	**0.51*****	**-0.25****	**-0.22****	—	
14. Average commuting time per day	**-0.16***	0.03	-0.02	0.12	0.04	-0.03	**0.25****	0.10	-0.03	**0.36*****	**-0.22****	**0.26****	**0.24***	

Note. MVPA, moderate-to-vigorous physical activity. Each value represents the Pearson's correlation coefficient. Gender (male = 0, female = 1) and education (junior high/high school = 0, beyond high school = 1) were treated as the dummy variables.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Supplementary Table 3. *Random Effects of Daily Analyses in the Association of Routine Work Time and Exercise Time at Baseline (Multilevel Models)*

	Estimated (SE) in Model 1	Estimated (SE) in Model 2
Random effects (standard deviations)		
Intercept for couples	612.0 (267.1)	713.4 (196.4)
Intercept for individuals	1177 (170.8)	893.3 (171.6)
Slope for daily routine work time	0.060 (0.012)	0.061 (0.012)
Residual	2620.3 (67.3)	2618.0 (67.1)

Note. SE, standard error. Dependent variable was exercise time per day (1,004 person-days). The fixed effects in Model 1 were daily routine work time (within-person level), gender, educational background, age, and overall routine work time (between-person level). In addition to the fixed effects in Model 2, the fixed effects in Model 2 included perceived exercise barriers and exercise self-efficacy (between-person level). The results of the fixed effects in each model are shown in Table 2 of the text.

Supplementary Table 4. *Random Effects of Daily Analyses in the Association of Routine Work Time With Moderate-to-Vigorous Physical Activity at Baseline (Multilevel Models)*

	Estimated (SE) in Model 1	Estimated (SE) in Model 2
Random effects (standard deviations)		
Intercept for couples	1005.3 (269.4)	764.0 (310.1)
Intercept for individuals	1818.2 (161.3)	1775.7 (158.5)
Slope for daily accelerometer wearing time	0.049 (0.01)	0.045 (0.009)
Slope for daily exercise time	0.228 (0.037)	0.237 (0.037)
Slope for daily routine work time	0.072 (0.007)	—
Slope for daily household time	—	0.082 (0.021)
Slope for daily sedentary work time	—	0.032 (0.011)
Slope for daily active work time	—	0.094 (0.012)
Slope for daily commuting time	—	0.071 (0.046)
Residual	1323.4 (37.9)	1168.9 (36.7)

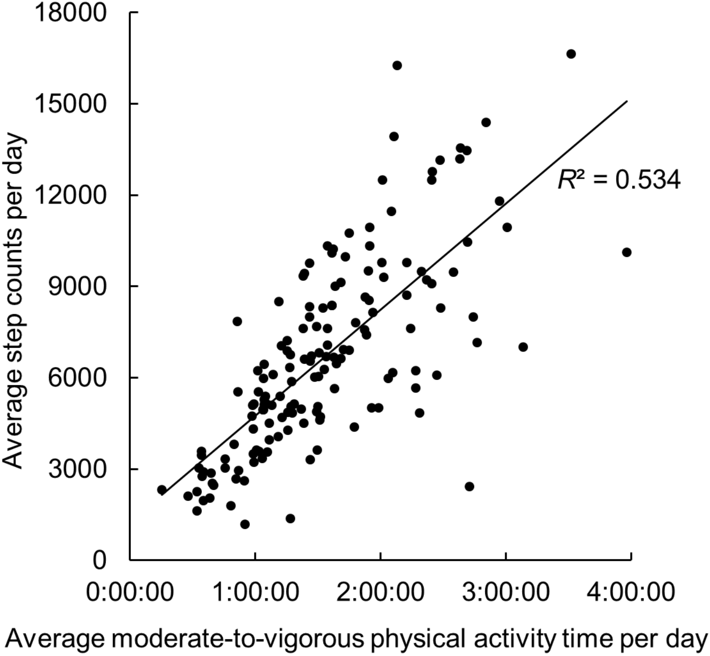
Note. SE, standard error. Dependent variable was time spent on moderate-to-vigorous physical activity per day. There were 998 valid person-days in Model 1 and 959 valid person-days in Model 2. The fixed effects in Model 1 were daily accelerometer wearing time, daily exercise time, daily routine work time (within-person level), gender, educational background, age, overall accelerometer wearing time, overall exercise time, and overall routine work time (between-person level). The fixed effects in Model 2 were daily accelerometer wearing time, daily exercise time, daily household time, daily sedentary work time, daily active work time, daily commuting time (within-person level), gender, educational background, age, overall household time, overall sedentary work time, overall active work time, and overall commuting time (between-person level). The results of the fixed effects in each model are

shown in Table 3 of the text.

Supplementary Table 5. *Random Effects of Daily Analyses in the Association of Routine Work Time With Step Counts at Baseline (Multilevel Models)*

	Estimated (SE) in Model 1	Estimated (SE) in Model 2
Random effects (standard deviations)		
Intercept for couples	842.5 (492.8)	676.0 (541.5)
Intercept for individuals	2367.8 (217.9)	2248.0 (208.3)
Slope for daily accelerometer wearing time	0.021 (0.025)	0.009 (0.063)
Slope for daily exercise time	0.429 (0.058)	0.444 (0.058)
Slope for daily routine work time	0.093 (0.011)	—
Slope for daily household time	—	0.126 (0.026)
Slope for daily sedentary work time	—	0.056 (0.016)
Slope for daily active work time	—	0.113 (0.016)
Slope for daily commuting time	—	0.177 (0.072)
Residual	1967.3 (56.6)	1783.8 (56.6)

Note. SE, standard error. Dependent variable was step counts per day. Valid person-days were 998 person-days in Model 1, and 959 person-days in Model 2. Fixed effects in Model 1 were daily accelerometer wearing time, daily exercise time, daily routine work time (within-person level), gender, educational background, age, overall accelerometer wearing time, overall exercise time, and overall routine work time (between-person level). The fixed effects in Model 2 were daily accelerometer wearing time, daily exercise time, daily household time, daily sedentary work time, daily active work time, daily commuting time (within-person level), gender, educational background, age, overall household time, overall sedentary work time, overall active work time, and overall commuting time (between-person level). The results of the fixed effects in each model are shown in Table 4 of the text.


18000
15000
12000
9000
6000
3000
0
Average step counts per day
R^2 = 0.534
0:00:00
1:00:00
2:00:00
3:00:00
4:00:00
Average moderate-to-vigorous physical activity time per day