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Original research

The effects of occupation on the daily physical activity and sedentary behavior of middle-aged workers in Korea: a cross-sectional study based on data from the Korea National Health and Nutrition Examination Survey

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ABSTRACT

Objectives

The World Health Organization (WHO) recommends that adults engage in regular moderate-to-vigorous-intensity physical activity (MVPA), muscle-strengthening activities (MSA), and minimize sedentary behavior. This study aimed to determine occupational effects on MVPA, MSA, and sedentary behavior in middle-aged Korean workers.

Design and setting

A cross-sectional study using data from the 7th Korea National Health and Nutrition Examination Survey (KNHANES, 2016–2018).

Participants

Workers aged between 40-69 years in Korea (n=6,359).

Outcome measures

Population-weighted proportions meeting the MVPA (≥150 min/week) and MSA (≥2 days/week) guidelines, and with high sedentary behavior (>7 hours/day) were calculated, and their associations with sociodemographic and work-related variables were assessed using multiple logistic regression analyses. Additionally, the estimated time spent on MVPA, MSA and sedentary behavior according to the occupation categories (white-, pink-, blue-collar) was calculated using analysis of covariance (ANCOVA).

Results

The MVPA level did not show a significant difference across the occupation categories. Blue-collar workers showed significantly lower MSA participation than white-collar and pink-collar workers (male, p=0.006; female, p=0.004; by ANCOVA). High sedentary behavior was significantly associated with white-collar occupations (p<0.001 by ANCOVA). Longer working hours were negatively associated with MVPA (OR=1.01; CI 1.01-1.02) and MSA (OR=1.01; CI 1.00-1.02). Workers with higher stress were less likely to participate in

MSA (male: OR=1.43; CI 1.10-1.86; female: OR=1.39; CI 1.08-1.80). Self-employed workers showed lower MVPA levels than employees (male: OR=1.26; CI 1.09-1.47; female: OR=1.36; CI 1.13-1.64). Daily workers compared to full-time workers (OR=0.38; CI 0.24-0.59) and temporary workers compared to regular workers (OR=0.75; CI 0.59-0.95) were associated with less sedentary behavior in men.

Conclusion

A number of work-related factors were associated with PA levels and sedentary behavior in middle-aged workers. The workplace is one of the critical elements to intervene in health promotion strategies.

Strengths and limitations of this study

- This is the first study in Korea to investigate the MVPA and MSA participation and sedentary behavior concurrently across occupation categories using national representative data.

- This study comprehensively investigated the effects of occupation on PA level and sedentary behavior regarding various socioeconomic confounding factors.

- This study assessed the MVPA level of three domains (occupational, transportation, and leisure-time) and sedentary behavior together to estimate overall PA status accurately.

- The MVPA level, MSA level, and degree of sedentary behavior were analyzed not only as dichotomous variables ("meeting the MVPA or MSA guideline" or "not meeting the MVPA or MSA guideline, "high sedentary" or "low sedentary") but also as continuous variables (time spent on MVPA, MSA, and sedentary behavior).

- Since the study design was cross-sectional, causality cannot be inferred.

INTRODUCTION

Physical inactivity is a worldwide public health problem and is responsible for about 6%-10% of the global burden of major chronic non-communicable diseases.[1] Until recently, physical activity (PA) recommendations primarily focused on moderate-to-vigorous-intensity physical activity (MVPA).[2] However, based on recent evidence, World Health Organization's (WHO) PA guidelines for public health now include muscle-strengthening activities (MSA) in addition to MVPA.[3] MSA provides additional metabolic health benefits[4] and prevents sarcopenia.[5] Moreover, there are cumulative health benefits by combining MVPA and MSA.[6] [7] Meeting guidelines for both activities compared to meeting the guideline for only one was associated with a lower risk of all-cause mortality in cohort studies.[8]

In addition, sedentary behavior has recently emerged as a potential independent risk factor distinct from insufficient PA for poor health.[9] The WHO guidelines state that the amount of time spent in sedentary should be limited and replaced with PA of any intensity. Previous large cohort studies have shown the detrimental effects of sedentary behavior on all-cause mortality,[10] metabolic syndrome, cardiovascular disease,[10 11] and mental health[12]. The association between prolonged sitting and adverse health outcomes remained significant even after adjusting for aerobic exercise time, indicating that people should be active daily and limit their sedentary time for optimal health benefits.[9 10 13]

Among the various socioeconomic factors related to PA, one of the prime determinants might be occupation. People spend most of their lives employed, and occupation largely influences people's activities, not only during work hours but also during their leisure time. Some studies have focused on assessing PA levels in association with occupation using representative national data.[14-21] However, most of the earlier studies did not focus concurrently on types of PA, such as MVPA and MSA, and sedentary behaviors, and analyses were limited to either work time or leisure time.[14-17 21] Therefore, the aim of this

study was to investigate the middle-aged workers' overall participation in MVPA, MSA, and sedentary behavior according to sociodemographic and work-related factors.

MATERIALS AND METHODS

Data collection and participants

This study was based on data from the 7th Korea National Health and Nutrition Examination Survey (KNHANES, 2016–2018). The KNHANES is a nationwide, multistage-stratified, and complex design survey on the health and nutrition of a representative sample of the entire population of the Republic of Korea (hereafter Korea). It is conducted annually by trained specialists under the supervision of the Korea Centers for Disease Control and Prevention (KCDC). Data from the health questionnaire survey are collected using self-reported questionnaires. Of the 24,269 participants in the 2016–2018 survey, 10,586 adults aged between 40 and 70 years were initially selected. Participants who were students or unemployed or who had responded that PA in their daily lives was limited due to physical or mental disorders were excluded. Finally, 6,359 participants were included in this study. Participants were missing data on PA (n=24); education level (n=1); income level (n=8); work time (n=11); working schedule (n=10); occupation category (n=7); working status/employment type/employment status (n=2); perception of stress (n=11); and source of stress (n=3).

Data collection was performed after approval by the Institutional Review Board (IRB) of the KCDC (approval number: 2018-01-03-P-A). The details of the survey and dataset used in this study are available in a public, open access KNHANES repository. (https://knhanes.cdc.go.kr/ knhanes/index.do).

Physical activity assessment

The study collected information on participants' PA levels composed of MVPA and MSA. PA levels were measured using the Korean version of the modified global physical activity questionnaire (K–GPAQ). The GPAQ was developed by the WHO for PA surveillance in countries and has acceptable reliability and validity.[22 23] The GPAQ was translated into a Korean version in 2013, which has established reliability and validity (Kappa, 0.416–0.669; Spearman's rho, 0.642–0.762).[24]

MVPA

The MVPA refers to the PA performed at over 3 METs (MET, Metabolic equivalent of task; 3 METs, three times the intensity of rest). The information on MVPA level was collected in three domains: occupational PA (OPA), transportation PA (TPA), and leisure time PA (LTPA).[25] The OPA refers to PA undertaken during paid or voluntary work including studying and household chores. The TPA refers to PA performed to get places such as walking or cycling. The LTPA is defined as PA that is not required as an essential activity of daily living such as sports, fitness, and recreational activities. The total MVPA level refers to the sum of OPA, TPA, and LTPA. Respondents reported their MVPA frequency (days) and duration (hours and minutes) in a typical week and were asked to report only activities that lasted for at least 10 continuous minutes. The PA level for each activity domain was estimated by multiplying the frequency by the duration. When summing the values, the minutes spent on vigorous-intensity PA (VPA) were multiplied by two. For OPA and LTPA, moderate-intensity PA (MPA) and VPA were asked separately, and for TPA, only MPA was asked. The VPA refers to activities that require hard physical effort and cause large increases in breathing or heart rate (PA performed at 6 or more METs), whereas the MPA refers to activities that require moderate physical effort and cause small increases in breathing or heart rate (PA performed between 3 and <6 METs). Example cards showing the typical activities

for each question were used to help the respondents understand the questions for consistent and valid measurements.

MSA

To assess MSA, respondents were asked, "Over the past 7 days, how many days did you do any physical activities specifically designed to strengthen your muscles such as sit-ups, push-ups, lifting weights or dumbells?".

Compliance with PA guidelines

The 2010 WHO "Global recommendations on physical activity for health" recommends that adults aged 18–64 years old and 65 years old and above engage in: (1) ≥150 min/week of MPA, ≥75 min/week of VPA or an equivalent combination of both; and (2) MSA at a moderate or greater intensity that involves all major muscle groups on two or more days a week. The study's participants were dichotomized as either "meeting the guideline" or "not meeting the guideline" depending on their adherence to each type of PA (MVPA and MSA).

Sedentary behaviors

Sedentary behaviors are defined as behaviors with low energy expenditure (≤1.5 METs), and are distinct from the simple absence of PA.[25] The amount of sedentary behavior was measured using the item in the K-GPAQ. Respondents reported their average time spent on sedentary behavior per day during a typical week. Sedentary behavior was defined as sitting or lying down while working, at home, moving from place to place, and during leisure activities excluding sleep. We defined sedentary behavior exceeding seven hours a day as "high sedentary", based on a meta-analysis showing an increased risk of all-cause mortality around seven to eight hours a day of sedentary time.[26]

Demographic and work-related variables

We analyzed the subjects' adherence to PA guidelines based on sociodemographic and work-related factors. The sociodemographic variables included age, sex, and education level ("below middle school graduate," "high school graduate," or "college graduate or higher"), location of residence ("urban" or "rural"), family structures ("single-person household" or "with members"), and quartiles of household income. Work-related factors included average work time per week, working schedule ("daytime worker" or "shift worker"), occupation category ("white-collar", "pink-collar", or "blue-collar"), working status ("employee", "self-employed", or "unpaid family worker"), employment type ("full-time", "part-time", or "daily worker"), employment status ("regular" or "temporary"), level of stress perception-1 ("low" or "high"), and level of stress perception-2 ("low" or "high-job related" or "high-other") . As for work-related variables, we collected the data based on the information about participants' "current" occupations. In the survey, occupation was classified into ten categories (manager, professionals and related worker, office worker, service worker, sales worker, agriculture/forestry/fishery, craft and related trades workers, machine operators and assemblers, labor workers, and soldier) according to the Korean standard classification of occupation (KSCO).[27] We further grouped types of occupation as white-collar (manager, professionals and related worker, office worker), pink-collar (service worker, sales worker), and blue-collar (agriculture/forestry/fishery, craft and related trades workers, machine operators and assemblers, labor workers, soldier). "Stress perception" was assessed as "high" when participants responded that they experienced "very much" or "much" stress. "Stress perception" measured overall stress regardless of stress sources. The 2018 KNHANES survey included another variable "source of stress" composed of 9 types of stress sources (i.e. economic problem, job stress, family, spouse, living environment, unemployment, health, family's health, and etc.). The second "stress perception" variable (stress perception-2) was

made by categorization of “high-job related”, “high-other”, and “low” based on whether the stress came from job stress or not in participants with “very much” or ‘much” stress.

Statistical analysis

All the statistical analyses were conducted with a complex sample analysis using weights according to the KCDC’s guidelines for using KNHANES’ raw data. The population-weighted numbers and estimated percentages of the “meeting the guideline” and "not meeting the guideline” groups for MVPA and MSA, and the “high sedentary” and the “low sedentary” groups were calculated. Sociodemographic factors and work-related factors were compared between the groups using the Rao-Scott chi-square test for categorical variables and the complex sample general linear model for continuous variables. Multiple logistic regression was used to examine the odds of not meeting the MVPA guideline, not meeting the MSA guideline, and high sedentary behavior. First, we performed the analysis by adjusting for age and each related factor (Model 1). Next, we performed an additional analysis by adjusting the variables that were statistically significant in Model 1 (Model 2). Analysis of covariance was used to compare the time spent on MVPA, MSA, and sedentary behavior, adjusted by sociodemographic variables that were significant in the previous analysis. The analyses were performed using SAS version 9.4 (SAS Institute, Inc., Cary, NC, USA), and SAS PROC SURVEY was used for complex weighting. P-values <0.05 were considered statistically significant.

Patients and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

RESULTS

Proportions of participants in the "Meeting WHO PA Guidelines" and "High Sedentary" groups

Among male workers, the proportion of participants who met the guidelines was 45.0% for MVPA and 26.5% for MSA; among female workers, the proportions were 40.60% for MVPA and 13.5% for MSA. The proportions for high sedentary group was 51.3% in male workers and 44.4% in female workers.

Differences in sociodemographic and work-related factors by PA guideline compliance and level of sedentary behavior

Unadjusted analyses indicated significant differences in a number of sociodemographic and work-related factors depending on adherence to the PA guidelines (Table 1 and Table 2). The education level, residential area, and household income were significantly associated with MVPA in male, and MSA and sedentary behavior in both sexes. Only residential area was associated with MVPA in female. Working hours was significantly associated with MVPA, MSA in both sexes and sedentary behavior in female. Occupation category was significantly associated with MVPA, MSA, and sedentary behavior. Stress perception was significantly associated with MSA and sedentary behavior in both sexes, and working schedule with sedentary behavior in female. Working status was significantly associated with MVPA in both sexes, employment type with MVPA and MSA, and employment status with MSA in male. Sedentary behavior was significantly associated with working status, employment type and status in both sexes.

Factors affecting compliance to PA guidelines

The risk factors for "not meeting the MVPA guideline" and "not meeting the MSA guideline" in middle-aged workers were investigated (Table 3 and Table 4). Men who had been educated up to middle school (OR=2.19; CI 1.80–2.67) and high school graduates (OR=1.30; CI 1.10–1.51) had a higher risk of not adhering to the MVPA guideline compared to those who had college degrees. Rural residents were less likely to meet the MVPA guideline than urban residents in both sexes (males: OR=1.27; CI 1.06–1.53; females: OR=1.74; CI 1.41–2.14). Workers not meeting the MVPA guideline worked longer hours than those who met the guideline (OR=1.01; CI 1.01–1.02). Self-employed workers of both sexes (males: OR=1.26; CI 1.09-1.47; females: OR=1.36; CI 1.13-1.64) and female unpaid family workers (OR=1.35; CI 1.02-1.78) were at a higher risk of not meeting the MVPA guideline.

Men who had been educated up to middle school were less likely to meet the MSA guideline than those who had college degrees (OR=1.94; CI 1.31–2.87). Rural residents were less likely to meet the MSA guideline than urban residents (males: OR=1.43; CI 1.04–1.96; females: OR=1.65; CI 1.20–2.27). Males in the lowest income quartile were less likely to meet the MSA guideline than those in the highest quartile (OR=1.77; CI 1.26–2.48). Workers not meeting the MSA guideline worked longer hours than those who met the guideline (OR=1.01; CI 1.00–1.02). Female blue-collar workers were at a higher risk of not meeting the MSA guideline compared to white-collar workers (OR=1.71; CI 1.30–2.24). Workers with higher stress were unlikely to practice the MSA guideline than those with lower stress (males: OR=1.43; CI 1.10–1.86; females: OR=1.39; CI 1.08–1.80).

Factors affecting high sedentary behavior

The risk factors for high sedentary behavior are shown in Table 3 and Table 4. Male high school graduates were less likely to show high sedentary behavior than those with college degrees (OR=0.69; CI 0.55–0.88). Male rural residents were at a lower risk of high sedentary

behavior (OR=0.57; CI 0.43–0.74). White-collar workers were at a greater risk of high sedentary behavior compared to pink- and blue-collar workers (OR=0.40; CI 0.28–0.59 for male pink-collar workers; OR=0.34; CI 0.27–0.44 for male blue-collar workers; OR=0.23; CI 0.18–0.30 for female pink-collar workers; OR=0.37; CI 0.28–0.48 for female blue-collar workers). Male daily workers compared to full-time workers (OR=0.38; CI 0.24–0.59) and male temporary workers compared to regular workers (OR=0.75; CI 0.59-0.95) were less likely to show high sedentary behavior.

Estimated time spent on MVPA, MSA and sedentary behavior by occupation category, adjusted by sociodemographic factors

The time spent on MVPA, MSA, and sedentary behavior, adjusted by age, education level, residential area, and income level were compared across occupation categories (Table 5 and figure 1). In both sexes, the total estimated time spent on MVPA did not differ by occupation categories. However, time spent in the occupational domain of MVPA (OPA) was significantly longer in male blue-collar workers than in other occupation categories in men ($p<0.001$), and time spent in the transportation domain of MVPA (TPA) was significantly longer in female blue-collar workers than pink-collar workers ($p=0.018$). Male pink-collar workers ($p=0.006$) and female white-collar workers ($p=0.004$) spent significantly more times in MSA than blue-collar workers. White-collar workers showed significantly more sedentary behavior than pink- and blue-collar workers in both sexes ($p<0.001$).

DISCUSSION

This study assessed Korean middle-aged workers' compliance with PA guidelines and the degree of the sedentary behavior in association with sociodemographic and work-related variables, particularly focusing on the influence of the occupation category. More than half of

the middle-aged workers did not meet the minimum recommended level of MVPA in both sexes. The MSA compliance rate was far less than that for MVPA, especially in women, which was about half the compliance rate in men. The average time for sedentary behavior was longer in men than in women.

The association between occupation category and total MVPA was investigated. While many previous studies focused exclusively on LTPA, this study assessed the total MVPA level to evaluate the overall MVPA status. Results showed that the differences in MVPA levels across the occupation categories became insignificant after adjusting for sociodemographic factors. This implies that sociodemographic factors are more important predictors of MVPA participation than occupation category. As occupation is closely intertwined with socioeconomic status, studying the association between occupation category and PA is complex and it is important to consider the confounding effects of socioeconomic factors.[28]

Previous studies have shown that white-collar workers have more LTPA than blue-collar workers.[14 15 17-19] However, the total MVPA level was higher in blue-collar workers than in white-collar workers in all ten studies included in a systematic review analysis.[15] This was because, although the level of LTPA in blue-collar workers was lower than in white-collar workers, much higher levels of OPA in blue-collar workers resulted in higher total MVPA.[16 19] This is inconsistent with our findings that there was no significant difference in the total MVPA and LTPA among occupation categories. In our study, male blue-collar workers did show significantly higher OPA than other occupation categories, but after summing TPA and LTPA, their MVPA levels did not significantly differ from other occupation categories. Along with technical evolution in industry, work-related physical exertion has been declining rapidly, and OPA contributed less to total MVPA than before.[29] Especially, in female workers, OPA accounted for a less significant portion, whereas TPA was the major

contributor to total MVPA. While LTPA is consistently associated with positive health benefits in previous research,[30] OPA remains controversial,[31] with some studies indicating negative health outcomes.[32] Therefore, regarding MVPA, LTPA should primarily be emphasized as a public health promotion strategy irrespective of occupation.

The blue-collar occupations were associated with significantly lower participation in MSA compared to white-collar or pink-collar occupations. Although a limited number of studies assessed MSA participation in relation to occupation category, our findings are consistent with prior studies.[14 33] It should be noted that there are some differences in the questionnaire items among the different types of MSA assessment tools.[34] The survey item we used in our study (How many days did you do any physical activities specifically designed to strengthen your muscles such as sit-ups, push-ups, lifting weights or dumbells?) is likely to have only assessed MSA performed during leisure time. The MSA during work time (e.g., moving heavy items, digging, construction work), on the other hand, might not have been counted when calculating the MSA level. This would have underestimated the actual level of MSA in blue-collar workers who might have accumulated some extent of MSA while working. Theoretically, attaining MSA within the occupational domain is possible and some occupational activities are associated with both MVPA and MSA.[35] However, in order to obtain optimal health benefits, MSA should be performed with adequate intensity and sufficient duration using all major muscle groups, which is only possible during leisure time.

White-collar workers had the longest sedentary time among occupation categories. Excessive sitting and insufficient PA during working hours have increasingly been recognized as a public health problem. Recent accelerometry-based studies showed that occupation categories of “office and administrative support”, “architecture/engineering”, and “computer/mathematical”, which are all white-collar occupations, were among the least favorable type of job when overall activities were assessed by accelerometry.[20 36] Therefore,

workplace PA interventions such as using sit-stand desks, and more break times to attend workplace exercise programs should be implemented as a public health promotion strategy, particularly in white-collar workers who have the longest sedentary time.[37]

Work-related factors, including working hours, working schedule, and stress perception were investigated. Those who worked for longer hours reported lower levels of participation in both MVPA and MSA than those who worked fewer hours. The role of working hours is especially important as the working hours reported by Korean adults are one of the longest among the member states of the Organization for Economic Co-operation and Development (OECD).[38] Previous evidence has indicated that working hours have a negative threshold effect on participation in MVPA, which means that the negative correlation between working hours and MVPA level becomes evident at the 45–50 hours/week level and above.[15] Shift work, compared to daytime work, did not show any association with PA level or sedentary behavior similar to previous findings.[19] This might be due to the heterogeneity present in different types of shift work (e.g. shifts with or without night work, shifts with or without rotation, etc.). Additionally, those who have higher overall stress participated less in MSA. Higher job strain had been shown to be associated with low PA levels in previous studies,[15 39] which is inconsistent with our finding that 'higher job stress' group did not show significant difference in PA participation compared with 'high stress from other sources' group and 'low stress' group. Consequently, reducing working hours and helping workers manage excessive stress regardless of stress sources are important to encourage workers to be physically active.

Working status (employee/self-employed/unpaid family worker) was significantly associated with workers' MVPA level. Self-employed workers compared to employees showed significantly lower participation in MVPA. There are two contradictory views on the health of self-employed workers.[40 41] One is that as self-employed workers have the authority

regarding their jobs, they demonstrate better health behaviors (e.g. physical activity, smoking). However, the other perspective exists that they are likely to be in poor health due to high levels of job demand and work intensity. Korea, in particular, has the 7th highest proportion of self-employed workers in the working population among the thirty-five OECD countries, and small-sized (less than 50 workers) businesses, which have poorer working conditions than larger enterprises,[42] occupy more than half of the total businesses.[43 44] These negative association of self-employment and health behavior would partly explain our result that self-employed workers demonstrated significantly lower PA levels. Employment status (full-time/part-time/daily workers, regular/temporary) also showed a significant association with sedentary behaviors. In men, full-time workers compared to daily workers, and regular workers compared to temporary workers engaged in sedentary behavior for significantly longer time. Female workers also showed similar patterns, but lost the statistical significance in the fully-adjusted model.

Strengths and limitations

The strength of our study is that we investigated the MVPA and MSA participation and sedentary behavior concurrently across occupation categories using national representative data. We assessed total MVPA level and sedentary behavior together to estimate overall PA status in middle-aged workers. Our results demonstrated the different PA patterns of middle-aged workers depending on the occupational factors, which would help develop worksite targeted intervention. Another strength is that we took into account various sociodemographic variables during the analysis, thereby provides more adequate presentation of the association between occupation and PA levels. However, our study also has several limitations. Self-report measurement of MVPA, MSA, and sedentary behavior might have recall bias. Under or over-reporting due to social desirability is possible. However, this limitation might not

significantly bias our results because the KNHANES uses standardized self-report instruments for public health surveillance and the recruited subject numbers were sufficient to decrease bias. The second limitation is that the inferences of causality could not have been determined because of the cross-sectional study design. Last, the data we used were limited to middle-aged individuals. However, previous studies have shown that sociodemographic correlates of PA participation change with the age of the studied population.[45] Therefore, we selected the middle-aged population for a more homogenous sample of the population. Moreover, as the middle-aged population is a critical age group for the prevention of multiple chronic health conditions, our findings would help to inform health promotion policies for the targeted population.

CONCLUSION

In conclusion, work-related factors, especially occupation category, were significantly associated with MVPA, MSA, and sedentary behavior in middle-aged workers. The workplace would offer a worthy setting for targeted interventions. As blue-collar workers are at risk of engaging in lower MSA, providing education and building facilities for MSA at work would be helpful. Work-site intervention to provide intermittent breaks to prolonged sitting is necessary for white-collar workers. Moreover, knowledge about work-related risk factors for physical inactivity to identify vulnerable subpopulations would help establish public health policies to reduce health inequalities.

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Contributors

Joo Hye Sung conceived of the study design and wrote substantial parts of the manuscript. Se Rhim Son contributed substantively to the data analysis. Seol-Hee Baek was responsible for quality assurance of the data and interpretation of these findings. Byung-Jo Kim conceived of and supervised the study, and contributed integrating key aspects of the study.

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Competing interests

None declared.

Patient consent for publication

Not required.

Ethics approval

Data collection was performed after approval by the Institutional Review Board (IRB) of the Korean Centers for Disease Control and Prevention (approval number: 2018-01-03-P-A).

Data sharing statement

The dataset used in this study are available in a public, open access KNHANES repository. (https://knhanes.cdc.go.kr/ knhanes/index.do).

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Figure legends

Figure 1. Comparisons of estimated time spent in MVPA (A), MSA (B) and sedentary behavior (C) adjusted by age, education level, residential area, and income level according to the type of occupation and sex in middle-aged workers in Korea. (A) For OPA, male blue-collar workers^{B} are significantly different from the white-^{A} and pink-collar workers^{A}. For TPA, female blue-collar workers^{b} are significantly different from female pink-collar workers^{a}. (B) Male pink-collar workers^{A} are significantly different from male blue-collar workers^{B}. Female white-collar workers^{a} are significantly different from female blue-collar workers^{b}. (C) White-collar workers^{Aa} are significantly different from pink-collar and blue-collar workers^{Bb} in both sexes. Error bars indicate 95% confidence intervals. MVPA, moderate-to-vigorous physical activity; OPA, occupational physical activity; TPA, transportation physical activity; LTPA, leisure-time physical activity; MSA, muscle-strengthening activities.

Table 1. Sociodemographic and work-related correlates of physical activity and sedentary behavior in middle-aged male workers

	Current study, n (Population-weighted estimates, %) *	Not meeting MVPA guideline %(95% CI)†	Meeting MVPA guideline‡ %(95% CI)†	P value	Not meeting MSA guideline %(95% CI)†	Meeting MSA guideline§ %(95% CI)†	P value	High sedentary (>7 hours) %(95% CI)†	Low sedentary (≤7 hours)¶ %(95% CI)†	P value
Total	3,306	55.0 (53.0-57.0)	45.0 (43.0-47.0)		73.5 (71.9-76.4)	26.5 (24.8-28.1)		51.3 (49.2-53.4)	48.7 (46.6-50.9)	
Age		52.2±0.2	51.3±0.2	0.002	51.6±0.2	52.4±0.3	0.012	51.1±0.2	52.6±0.2	<0.001
Education				<0.001			<0.001			<0.001
Below middle school	709 (15.4)	71.0 (66.8-75.2)	29.0 (24.8-33.2)		84.8 (81.6-88.0)	15.2 (12.0-18.4)		37.1 (32.1-42.0)	63.0 (58.0-67.9)	
High school	1,133 (35.0)	57.1 (53.7-60.5)	42.9 (39.5-46.3)		74.4 (71.6-77.2)	25.6 (22.8-28.4)		42.6 (39.3-45.8)	57.4 (54.2-60.7)	
College or higher	1,464 (49.7)	48.6 (45.8-51.4)	51.4 (48.6-54.2)		69.4 (67.0-71.8)	30.6 (28.2-33.0)		61.9 (59.1-64.6)	38.1 (35.4-40.9)	
Residence				0.002			0.002			<0.001
Urban	2,660 (83.9)	53.7 (51.5-55.9)	46.3 (44.2-48.5)		72.4 (70.5-74.2)	27.6 (25.8-29.5)		54.5 (52.1-56.9)	45.5 (43.1-48.0)	
Rural	646 (16.1)	62.0 (57.2-66.7)	38.1 (33.3-42.8)		79.7 (75.8-83.5)	20.3 (16.5-24.2)		34.7 (29.8-39.5)	65.4 (60.5-70.2)	
Family structure				0.936			0.703			0.171
Single	264 (7.2)	54.7 (47.8-61.6)	45.3 (38.4-52.2)		72.4 (66.1-78.7)	27.6 (21.3-33.9)		46.4 (39.2-53.6)	53.6 (46.4-60.8)	
With	3,042	55.0	45.0		73.6	26.4		51.7	48.3	

members	(92.8)	(52.9-57.1)	(42.9-47.1)		(71.9-75.4)	(24.7-28.1)		(49.4-53.9)	(46.1-50.6)	
Income				0.008			<0.001			<0.001
1st (lowest)	638 (19.7)	59.6 (55.2-63.9)	40.5 (36.1-44.8)		80.5 (77.0-84.0)	19.5 (16.0-23.0)		40.6 (36.3-44.9)	59.4 (55.2-63.7)	
2nd	871 (26.4)	57.1 (53.4-60.8)	42.9 (39.3-46.6)		74.0 (70.9-77.1)	26.0 (22.9-29.1)		46.6 (42.7-50.5)	53.4 (49.5-57.3)	
3rd	902 (27.6)	54.4 (50.7-58.1)	45.6 (41.9-49.3)		75.0 (71.9-78.0)	25.0 (22.0-28.1)		54.2 (50.5-57.9)	45.8 (42.1-49.5)	
4th (highest)	891 (26.2)	50.2 (46.4-54.0)	49.8 (46.0-53.6)		66.5 (63.0-70.1)	33.5 (29.9-37.0)		61.2 (57.2-65.2)	38.8 (34.9-42.8)	
Work time per week		46.6±0.4	44.2±0.4	<0.001	46.1±0.3	43.7±0.5	<0.001	45.2±0.4	45.9±0.5	0.214
Working schedule				0.446			0.485			0.362
Day-time worker	2,872 (86.4)	55.4 (53.2-57.6)	44.6 (42.5-46.8)		73.8 (72.0-75.6)	26.2 (24.4-28.0)		51.7 (49.4-54.0)	48.3 (46.0-50.6)	
Shift worker	428 (13.4)	53.0 (47.4-58.6)	47.0 (41.5-52.6)		71.9 (67.1-76.8)	28.1 (23.2-32.9)		49.0 (43.7-54.4)	51.0 (45.6-56.3)	
Occupation category				<0.001			<0.001			<0.001
White-collar	1,268 (44.2)	48.9 (46.1-51.7)	51.1 (48.3-53.9)		69.1 (66.5-71.7)	31.0 (28.4-33.5)		66.1 (63.3-68.9)	33.9 (31.1-36.7)	
Pink-Collar	395 (13.2)	53.6 (48.2-59.0)	46.4 (41.0-51.8)		67.5 (62.6-72.5)	32.5 (27.6-37.4)		42.1 (36.9-47.4)	57.9 (52.6-63.1)	
Blue-collar	1,638 (42.5)	61.8 (58.8-64.8)	38.3 (35.3-41.3)		80.1 (77.7-82.5)	19.9 (17.5-22.3)		38.7 (35.6-41.8)	61.3 (58.2-64.4)	
Working status				<0.001			0.872			0.007
Employee	2,047 (63.9)	52.1 (49.7-54.6)	47.9 (45.4-50.4)		73.2 (71.0-75.4)	26.8 (24.6-29.1)		53.3 (50.7-56.0)	46.7 (44.1-49.3)	
Self-employed	1,195 (34.0)	59.8 (56.7-62.9)	40.2 (37.1-43.3)		74.2 (71.4-77.0)	25.8 (23.0-28.6)		48.5 (44.9-52.1)	51.5 (47.9-55.1)	

									28
Unpaid family workers	63 (2.1)	65.0 (52.8-77.2)	35.0 (22.8-47.2)		74.5 (60.2-88.8)	25.5 (11.2-39.8)		34.7 (20.8-48.6)	65.4 (51.4-79.3)	
Employment type				0.002			0.031			<0.001
Full-time	1,693 (84.0)	51.1 (48.4-53.9)	48.9 (46.2-51.6)		72.0 (69.5-74.4)	28.0 (25.6-30.5)		58.5 (55.7-61.3)	41.5 (38.7-44.3)	
Part-time	186 (8.4)	65.7 (58.5-72.9)	65.7 (58.5-72.9)		81.4 (75.2-87.7)	18.6 (12.4-24.8)		34.3 (26.8-41.7)	65.8 (58.3-73.2)	
Daily workers	168 (7.7)	48.4 (39.6-57.2)	48.4 (39.6-57.2)		77.1 (69.6-84.6)	22.9 (15.4-30.4)		18.0 (12.1-23.9)	82.1 (76.2-88.0)	
Employment status				0.192			0.005			<0.001
Regular	1,266 (65.2)	51.0 (47.9-54.1)	49.0 (45.9-52.1)		70.9 (68.1-73.8)	29.1 (26.2-31.9)		61.8 (58.7-65.0)	38.2 (35.1-41.3)	
Temporary	781 (34.8)	54.3 (50.4-58.1)	45.7 (41.9-49.6)		77.4 (74.0-80.7)	22.7 (19.3-26.0)		37.5 (33.7-41.3)	62.5 (58.7-66.3)	
Stress perception-1				0.266			0.007			<0.001
Low	2,538 (76.7)	54.4 (52.1-56.7)	45.6 (43.3-47.9)		72.2 (70.3-74.2)	27.8 (25.8-29.8)		49.2 (46.8-51.6)	50.8 (48.4-53.2)	
High	764 (23.2)	57.0 (53.2-60.8)	43.0 (39.2-46.8)		78.0 (74.7-81.3)	22.0 (18.7-25.4)		58.2 (54.2-62.2)	41.8 (37.9-45.8)	
Stress perception-2				0.120			0.180			0.259
Low	889 (77.7)	56.2 (52.4-60.1)	43.8 (39.9-47.6)		71.7 (68.1-75.2)	28.4 (24.8-31.9)		50.2 (46.1-54.3)	49.8 (45.7-53.9)	
High-job related	108 (9.2)	67.3 (57.4-77.2)	32.7 (22.8-42.6)		77.1 (67.3-86.8)	23.0 (13.2-32.7)		58.9 (48.9-69.0)	41.1 (31.0-51.1)	
High-other	149 (13.2)	53.4 (44.5-62.3)	46.6 (37.7-55.6)		79.4 (71.9-87.0)	20.6 (13.1-28.1)		52.9 (44.4-61.5)	47.1 (38.5-55.6)	

*Values are presented as unweighted number (population-weighted estimated percentage).

†Values are presented as population-weighted estimated percentage (95% CI) or mean ± standard deviation

‡Participants who reported engaging in at least 150 min per week of moderate-intensity physical activity or 75 min of vigorous-intensity physical activity per week, or an equivalent combination of both

§Participants who reported participating in muscle-strengthening physical activity at least two times per week.

¶'Low-sedentary' indicates participants who reported to spend ≤7hours/day in sedentary behaviors.

CI, confidence interval; MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous aerobic physical activity

Table 2. Sociodemographic and work-related correlates of physical activity and sedentary behavior in middle-aged female workers

	Current study, n (Population-weighted estimates, %) *	Not meeting MVPA guideline %(95% CI)†	Meeting MVPA guideline‡ %(95% CI)†	P value	Not meeting MSA guideline %(95% CI)†	Meeting MSA guideline§ %(95% CI)†	P value	High sedentary (>7 hours) %(95% CI)†	Low sedentary (≤7 hours)¶ %(95% CI)†	P value
Total	3,053	59.4 (57.4-61.4)	40.6 (38.6-42.6)		86.5 (85.0-88.0)	13.5 (12.0-15.0)		44.4 (42.2-46.6)	55.6 (53.4-57.8)	
Age		52.3±0.2	51.8±0.3	0.085	52.1±0.2	51.8±0.4	0.548	51.0±0.2	52.9±0.2	<0.001
Education				0.068			0.013			<0.001
Below middle school	964 (26.3)	63.5 (59.7-67.2)	36.5 (32.8-40.3)		89.1 (86.9-91.3)	10.9 (8.7-13.1)		33.0 (29.2-36.8)	67.0 (63.2-70.8)	
High school	1,166 (40.4)	57.9 (54.4-61.3)	42.1 (38.7-45.6)		86.9 (84.7-89.2)	13.1 (10.8-15.3)		42.9 (39.6-46.1)	57.2 (53.9-60.4)	
College or higher	922 (33.3)	58.0 (54.5-61.5)	42.0 (38.5-45.5)		84.0 (81.3-86.7)	16.0 (13.3-18.7)		55.3 (51.3-59.3)	44.7 (40.7-48.7)	
Residence				<0.001			0.002			<0.001
Urban	2,468 (84.2)	57.5 (55.2-59.7)	42.5 (40.3-44.8)		85.6 (83.9-87.2)	14.5 (12.8-16.1)		46.8 (44.3-49.3)	53.2 (50.7-55.7)	
Rural	585 (15.8)	69.7 (64.9-74.5)	30.3 (25.5-35.1)		91.6 (88.7-94.5)	8.4 (5.5-11.3)		31.6 (26.7-36.4)	68.4 (63.6-73.3)	
Family structure				0.439			0.438			0.543
Single	279 (7.6)	56.7 (49.6-63.9)	43.3 (36.1-50.4)		84.8 (80.1-89.4)	15.2 (10.6-19.9)		42.2 (35.0-49.5)	57.8 (50.6-65.0)	
With members	2,774 (92.4)	59.6 (57.5-61.7)	40.4 (38.3-42.5)		86.7 (85.1-88.2)	13.4 (11.8-14.9)		44.6 (42.2-46.9)	55.4 (53.1-57.8)	
Income				0.282			0.003			<0.001
1st	674	62.3	37.3		90.1	10.0		37.9	62.1	

(lowest)	(22.2)	(58.4-67.0)	(33.0-41.6)		(87.6-92.5)	(7.5-12.4)		(33.9-41.9)	(58.1-66.1)	
2nd	827 (26.7)	60.0 (56.1-63.9)	40.0 (36.1-43.9)		87.6 (85.0-90.2)	12.4 (9.8-15.1)		44.2 (40.3-48.0)	55.9 (52.0-59.7)	
3rd	779 (26.2)	57.6 (53.8-61.4)	42.4 (38.6-46.2)		86.5 (83.8-89.2)	13.6 (10.9-16.3)		42.8 (38.7-47.0)	57.2 (53.0-61.3)	
4th (highest)	769 (24.7)	57.7 (53.5-61.9)	42.3 (38.1-46.5)		82.5 (79.1-85.9)	17.5 (14.1-20.9)		52.6 (48.4-56.7)	47.5 (43.3-51.6)	
Work time per week		39.5±0.5	35.7±0.5	<0.001	38.3±0.4	35.6±1.0	0.009	36.9±0.5	38.7±0.5	0.011
Working schedule				0.456			0.593			0.001
Day-time worker	2,539 (82.8)	59.0 (56.8-61.3)	41.0 (38.8-43.2)		86.7 (85.1-88.2)	13.3 (11.8-14.9)		45.9 (43.4-48.3)	54.1 (51.7-56.6)	
Shift worker	510 (17.1)	61.2 (56.1-66.2)	38.9 (33.8-43.9)		85.7 (82.1-89.3)	14.3 (10.7-17.9)		37.0 (32.2-41.9)	63.0 (58.1-67.8)	
Occupation category				0.007			<0.001			<0.001
White-collar	1,185 (40.1)	57.5 (54.4-60.6)	42.5 (39.4-45.6)		83.7 (81.2-86.1)	16.3 (13.9-18.8)		58.9 (55.4-62.3)	41.2 (37.7-44.6)	
Pink-collar	985 (32.5)	63.9 (60.9-67.0)	36.1 (33.0-39.1)		86.5 (84.1-88.9)	13.5 (11.1-15.9)		34.9 (31.3-38.5)	65.1 (61.5-68.7)	
Blue-collar	881 (27.4)	56.8 (52.6-60.9)	43.2 (39.1-47.4)		90.7 (88.6-92.9)	9.3 (7.1-11.4)		34.4 (30.5-38.4)	65.6 (61.6-69.6)	
Working status				<0.001			0.113			0.02
Employee	2,094 (69.8)	56.3 (53.8-58.7)	43.8 (41.3-46.2)		87.0 (85.3-88.7)	13.0 (11.3-14.7)		45.8 (43.2-48.3)	54.3 (51.7-56.8)	
Self-employed	659 (21.3)	66.0 (61.8-70.1)	34.0 (29.9-38.2)		84.0 (80.7-87.2)	16.1 (12.8-19.3)		43.8 (39.2-48.4)	56.2 (51.6-60.8)	
Unpaid family workers	299 (8.9)	68.3 (61.6-75.0)	31.8 (25.1-38.4)		88.8 (84.7-92.9)	11.2 (7.1-15.3)		35.2 (28.2-42.1)	64.9 (57.9-71.8)	

Employment type				0.254			0.309		0.012
Full-time	1,373 (65.3)	55.5 (52.4-58.5)	44.6 (41.5-47.6)		86.2 (84.1-88.2)	13.8 (11.8-15.9)		48.5 (45.2-51.7)	51.6 (48.3-54.8)
Part-time	534 (26.0)	56.2 (51.5-60.8)	43.8 (39.2-48.5)		88.2 (85.1-91.2)	11.8 (8.8-14.9)		40.4 (35.6-45.2)	59.6 (54.8-64.4)
Daily worker	187 (8.8)	62.5 (54.8-70.2)	37.5 (29.8-45.2)		89.7 (84.9-94.6)	10.3 (5.4-15.1)		41.4 (33.6-49.2)	58.6 (50.8-66.5)
Employment status				0.165			0.665		<0.001
Regular	661 (32.1)	53.9 (49.5-58.2)	46.2 (41.8-50.5)		86.5 (83.8-89.2)	13.5 (10.8-16.2)		55.5 (51.1-59.9)	44.5 (40.1-48.9)
Temporary	1,433 (67.9)	57.4 (54.5-60.3)	42.6 (39.7-45.5)		87.2 (85.2-89.3)	12.8 (10.7-14.8)		41.1 (38.1-44.1)	58.9 (55.9-61.9)
Stress perception-1				0.090			0.020		0.029
Low	2,244 (73.5)	58.4 (56.0-60.7)	41.7 (39.3-44.0)		85.5 (83.8-87.3)	14.5 (12.7-16.2)		43.0 (40.4-45.6)	57.0 (54.4-59.6)
High	802 (26.3)	62.2 (58.4-66.0)	37.8 (34.0-41.6)		89.1 (86.7-91.5)	10.9 (8.5-13.3)		48.5 (44.2-52.8)	51.5 (47.2-55.8)
Stress perception-2				0.402			0.451		0.465
Low	813 (74.2)	60.3 (56.4-64.3)	39.7 (35.7-43.6)		84.3 (81.4-87.3)	15.7 (12.7-18.6)		45.6 (41.2-50.0)	54.5 (50.0-58.8)
High-job related	94 (8.9)	64.4 (53.4-75.5)	35.6 (24.6-46.6)		89.5 (82.5-96.5)	10.5 (3.5-17.5)		51.5 (40.7-62.4)	48.5 (37.6-59.3)
High-other	193 (16.9)	66.3 (58.0-74.7)	33.7 (25.4-42.0)		86.4 (80.5-92.3)	13.6 (7.7-19.6)		50.3 (40.4-60.1)	49.8 (39.9-59.6)

*Values are presented as unweighted number (population-weighted estimated percentage).

†Values are presented as population-weighted estimated percentage (95% CI) or mean ± standard deviation

‡Participants who reported engaging in at least 150 min per week of moderate-intensity physical activity or 75 min of vigorous-intensity physical

activity per week, or an equivalent combination of both

§Participants who reported participating in muscle-strengthening physical activity at least two times per week

¶'Low-sedentary' indicates participants who reported to spend ≤7hours/day in sedentary behaviors.

CI, confidence interval; MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous aerobic physical activity

Table 3. Factors associated with not meeting PA guidelines and high sedentary time in male middle-aged workers

	Not meeting "MVPA guideline"		Not meeting "MSA guideline"		High sedentary	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Explanatory variables	**OR(95% CI)**	**OR(95% CI)**	**OR(95% CI)**	**OR(95% CI)**	**OR(95% CI)**	**OR(95% CI)**
Demographic factor						
Education						
Below middle school	2.52(2.04-3.12)	2.19(1.80-2.67)	2.91(2.27-3.74)	1.94(1.31-2.87)	0.37(0.30-0.45)	0.95(0.69-1.32)
High school	1.40(1.20-1.64)	1.30(1.10-1.51)	1.31(1.10-1.57)	1.04(0.80-1.35)	0.46(0.39-0.54)	0.69(0.55-0.88)
College or higher	(ref.)	(ref.)	(ref.)	(ref.)	(ref.)	(ref.)
Residential area						
Urban	(ref.)	(ref.)	(ref.)	(ref.)	(ref.)	(ref.)
Rural	1.47(1.23-1.76)	1.27(1.06-1.53)	1.82(1.46-2.28)	1.43(1.04-1.96)	0.46(0.38-0.55)	0.57(0.43-0.74)
Quartiles of income						
1st(lowest)	1.54(1.25-1.90)		1.98(1.55-2.52)	1.77(1.26-2.48)	0.44(0.36-0.55)	
2nd	1.35(1.12-1.64)		1.41(1.15-1.74)	1.12(0.84-1.49)	0.55(0.46-0.67)	
3rd	1.21(1.00-1.46)		1.36(1.11-1.67)	1.25(0.96-1.63)	0.72(0.60-0.87)	
4th(highest)	(ref.)		(ref.)	(ref.)	(ref.)	
Occupational factor						
Work time per week	1.01(1.01-1.02)	1.01(1.01-1.02)	1.01(1.00-1.02)	1.01(1.00-1.02)		
Occupation category						
White-collar	(ref.)		(ref.)	(ref.)	(ref.)	(ref.)
Pink-collar	1.34(1.07-1.69)		0.96(0.75-1.23)	0.78(0.52-1.18)	0.33(0.26-0.42)	0.40(0.28-0.59)
Blue-collar	1.60(1.37-1.86)		2.04(1.71-2.44)	1.27(0.97-1.67)	0.27(0.23-0.32)	0.34(0.27-0.44)
Working status						
Employee	(ref.)	(ref.)			(ref.)	

Self-employed	1.39(1.20-1.61)	1.26(1.09-1.47)		0.82(0.71-0.95)	
Unpaid family worker	1.79(1.05-3.04)	1.44(0.84-2.47)		0.54(0.32-0.90)	
Employment type					
Full-time	(ref.)	(ref.)		(ref.)	(ref.)
Part-time	1.32(0.97-1.81)	1.64(1.13-2.39)		0.45(0.33-0.62)	0.70(0.49-1.01)
Daily worker	0.96(0.70-1.33)	1.63(1.10-2.42)		0.19(0.13-0.28)	0.38(0.24-0.59)
Employment status					
Regular		(ref.)		(ref.)	(ref.)
Temporary		1.64(1.30-2.07)		0.41(0.33-0.50)	0.75(0.59-0.95)
Stress perception					
Low		(ref.)	(ref.)	(ref.)	(ref.)
High		1.34(1.10-1.63)	1.43(1.10-1.86)	1.13(1.13-1.57)	1.24(0.98-1.56)

CI, confidence interval; MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous aerobic physical activity; OR, odds ratio

Model 1 was adjusted for age.

Model 2 was adjusted for variables that were statistically significant in Model 1.

Table 4. Factors associated with not meeting PA guidelines and high sedentary time in female middle-aged workers

	Not meeting "MVPA guideline"		Not meeting "MSA guideline"		High sedentary	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Explanatory variables	**OR(95% CI)**	**OR(95% CI)**	**OR(95% CI)**	**OR(95% CI)**	**OR(95% CI)**	**OR(95% CI)**
Demographic factor						
Education						
Below middle school			1.58(1.14-2.20)		0.44(0.35-0.55)	0.82(0.60-1.11)
High school			1.11(0.87-1.43)		0.61(0.51-0.73)	1.10(0.85-1.41)
College or higher			(ref.)		(ref.)	(ref.)
Residential area						
Urban	(ref.)	(ref.)	(ref.)	(ref.)	(ref.)	(ref.)
Rural	1.84(1.51-2.24)	1.74(1.41-2.14)	1.89(1.38-2.59)	1.65(1.20-2.27)	0.61(0.50-0.74)	0.78(0.60-1.03)
Quartiles of income						
1st(lowest)			1.56(1.15-2.12)		0.58(0.47-0.72)	
2nd			1.28(0.97-1.69)		0.70(0.58-0.86)	
3rd			1.24(0.94-1.65)		0.66(0.54-0.80)	
4th(highest)			(ref.)		(ref.)	
Occupational factor						
Work time per week	1.01(1.01-1.02)	1.01(1.01-1.02)	1.01(1.00-1.02)	1.01(1.00-1.02)	0.99(0.99-1.00)	
Working schedule						
Day-time worker					(ref.)	(ref.)
Shift worker					0.77(0.64-0.94)	0.80(0.62-1.03)
Occupation category						
White-collar	(ref.)		(ref.)	(ref.)	(ref.)	(ref.)
Pink-collar	1.07(0.89-1.29)		1.25(0.97-1.61)	1.09(0.85-1.39)	0.28(0.23-0.34)	0.23(0.18-0.30)

Blue-collar	0.93(0.76-1.13)		2.04(1.52-2.74)	1.71(1.30-2.24)	0.32(0.27-0.40)	0.37(0.28-0.48)
Working status						
Employee	(ref.)	(ref.)			(ref.)	
Self-employed	1.50(1.25-1.81)	1.36(1.13-1.64)			1.05(0.88-1.25)	
Unpaid family worker	1.74(1.33-2.26)	1.35(1.02-1.78)			0.61(0.47-0.79)	
Employment type						
Full-time					(ref.)	
Part-time					0.86(0.70-1.05)	
Daily worker					0.84(0.61-1.16)	
Employment status						
Regular					(ref.)	
Temporary					0.66(0.54-0.80)	
Stress perception						
Low			(ref.)	(ref.)	(ref.)	
High			1.41(1.10-1.82)	1.39(1.08-1.80)	1.13(0.96-1.34)	

CI, confidence interval; MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous aerobic physical activity; OR, odds ratio

Model 1 was adjusted for age.

Model 2 was adjusted for variables that were statistically significant in Model 1.

Table 5. Adjusted time spent for physical activity and sedentary behavior by sex and occupational classification

	White-collar	Pink-collar	Blue-collar	P value*	Post Hoc
Male					
MVPA (min/week)	232.4±23.6	252.1±26.7	283.2±22.7	0.2	
OPA	36.3±16.8	62.9±16.7	117.1±18.9	<0.001	White-Blue, Pink-Blue
TPA	109.9±9.5	88.3±9.4	91.8±6.8	0.139	
LTPA	86.2±9.2	101.5±14.6	73.9±7.8	0.250	
MSA (days/week)	1.0±0.1	1.1±0.1	0.7±0.1	0.006	Pink - Blue
Sedentary time (min/day)	485.3±9.1	406.6±11.6	394.7±7.0	<0.001	White – Pink, White - Blue
Female					
MVPA (min/week)	174.1±22.8	159.0±12.7	190.7±14.8	0.1	
OPA	32.8±20.6	29.4±9.3	38.7±9.3	0.597	
TPA	100.1±9.5	85.4±7.7	114.2±9.4	0.018	Pink – Blue
LTPA	41.2±5.3	44.2±4.8	37.7±4.8	0.564	
MSA (days/week)	0.6±0.1	0.4±0.1	0.3±0.0	0.004	White - Blue
Sedentary time (min/day)	466.0±9.4	372.1±8.7	377.2±8.8	<0.001	White – Pink, White - Blue

MVPA, moderate-to-vigorous aerobic physical activity; MSA, muscle-strengthening activity
Data were presented as mean ± standard error.

*The p-values are derived by ANCOVA adjusted for age, education level, residential area, and income level.

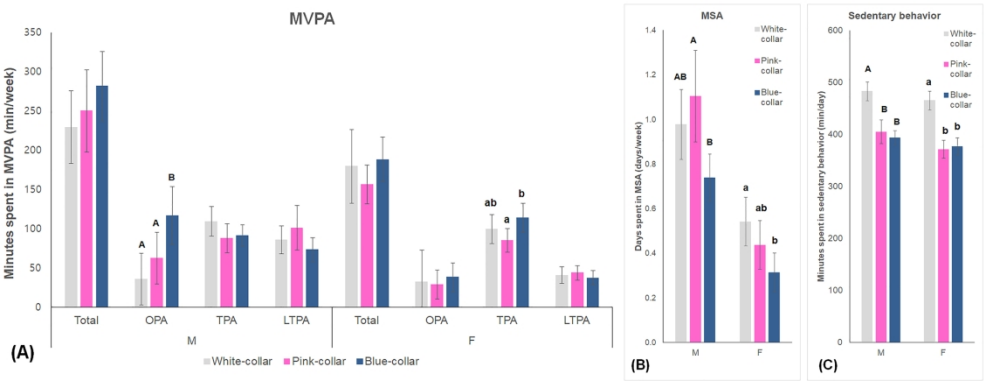

Figure 1. Comparisons of estimated time spent in MVPA (A), MSA (B) and sedentary behavior (C) adjusted by age, education level, residential area, and income level according to the type of occupation and sex in middle-aged workers in Korea. (A) For OPA, male blue-collar workers^{B} are significantly different from the white-^{A} and pink-collar workers^{A}. For TPA, female blue-collar workers^{b} are significantly different from female pink-collar workers^{a}. (B) Male pink-collar workers^{A} are significantly different from male blue-collar workers^{B}. Female white-collar workers^{a} are significantly different from female blue-collar workers^{b}. (C) White-collar workers^{Aa} are significantly different from pink-collar and blue-collar workers^{Bb} in both sexes. Error bars indicate 95% confidence intervals. MVPA, moderate-to-vigorous physical activity; OPA, occupational physical activity; TPA, transportation physical activity; LTPA, leisure-time physical activity; MSA, muscle-strengthening activities.

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Title/Abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page No#5
Objectives	3	State specific objectives, including any prespecified hypotheses	Page No#5~6
Methods			
Study design	4	Present key elements of study design early in the paper	Page No#6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page No#6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page No#6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page No#6~#9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page No#6~8
Bias	9	Describe any efforts to address potential sources of bias	Page No#7
Study size	10	Explain how the study size was arrived at	Page No#6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page No#7~8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page No#9~10
		(*b*) Describe any methods used to examine subgroups and interactions	Page No#9~10
		(*c*) Explain how missing data were addressed	Page No#9~10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Page No#9~10
		(*e*) Describe any sensitivity analyses	Page No#9~10
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page No#6
		(b) Give reasons for non-participation at each stage	Page No#6
		(c) Consider use of a flow diagram	Page No#6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page No#10~11

		(b) Indicate number of participants with missing data for each variable of interest	Page No#6
Outcome data	15*	Report numbers of outcome events or summary measures	Page No#10~11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page No#10~13
		(*b*) Report category boundaries when continuous variables were categorized	Page No#7~8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Irrelevant
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page No#12~13
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page No#13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page No#17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page No#13~16
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page No#13~16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page No#18

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Response to editors' comments:

Comment 1:
The temporality between occupational and physical activity surveyed is unclear. It is also not clear why the study subjects were initially selected aged 40-70, which caused losing some workers aged less than 40 and including possibly inactive workers aged 60 or 65 and over considering retirement age.

Response:
We analyzed the data based on the information about study subjects' "current" occupations. Since it is the workers' current occupations, not former ones, which affect their patterns of daily lives at the time the survey was conducted, the physical activity status and amount of sedentary behaviors were also regarded to be affected by their current occupations.
We clarified this point in the method section.

In the "Materials and methods – Demographic and work-related variables" section,

"…Work-related factors included average work time per week, working schedule ("daytime worker" or "shift worker"), occupation category ("white-collar", "pink-collar", or "blue-collar"), working status ("employee", "self-employed", or "unpaid family worker"), employment type ("full-time", "part-time", or "daily worker"), employment status ("regular" or "temporary"), and level of stress perception ("low" or "high"). In the survey, occupation was classified into ten categories (manager, professionals and related worker, office worker, service worker, sales worker, agriculture/forestry/fishery, craft and related trades workers, machine operators and assemblers, labor workers, and soldier) according to the Korean standard classification of occupation (KSCO)..."

⇒ "…Work-related factors included average work time per week, working schedule ("daytime worker" or "shift worker"), occupation category ("white-collar", "pink-collar", or "blue-collar"), working status ("employee", "self-employed", or "unpaid family worker"), employment type ("full-time", "part-time", or "daily worker"), employment status ("regular" or "temporary"), and level of stress perception ("low" or "high"). As for work-related variables, we collected the data based on the information about participants' "current" occupations. In the survey, occupation was classified into ten categories (manager, professionals and related worker, office worker, service worker, sales worker, agriculture/forestry/fishery, craft and related trades workers, machine operators and assemblers, labor workers, and soldier) according to the Korean standard classification of occupation (KSCO)…"

Also, only those who are currently working and not retired were included in the analysis. We mentioned in the "materials and methods – data collection and participants" section that we excluded participants who responded to be unemployed.

As mentioned in the limitation section, the reason that the study subjects were selected as 40-70 years of age was that previous studies have shown that sociodemographic correlates of physical activity participation changed with the age of the studied population, and middle-aged population is a critical age group for the prevention of multiple chronic health conditions.

Comment 2:

Although the study title is the effect of occupation, the findings were not sufficiently focused on occupational factors. We think the authors need to more thoroughly investigate the occupational information for this topic.

Response:
We analyzed several work-related factors, such as occupational category, working hours, working schedule, and stress perception. We had additional information about the working status ("employee", "self-employed", or "unpaid family worker"), employment type ("full-time", "part-time", or "daily worker"), employment status ("regular" or "temporary"). We added these variables to our analysis.

In Abstract,

"…The MVPA level did not show a significant difference across the occupation categories. Blue-collar workers showed significantly lower MSA participation than white-collar and pink-collar workers (male, p=0.006; female, p=0.004; by ANCOVA). High sedentary behavior was significantly associated with white-collar occupations (p<0.001 by ANCOVA). Longer working hours were negatively associated with MVPA (OR=1.01; CI 1.01-1.02) and MSA (OR=1.01; CI 1.00-1.02). Workers with higher stress were less likely to participate in MSA (male: OR=1.43; CI 1.10-1.86; female: OR=1.39; CI 1.08-1.80)…"

⇒"…The MVPA level did not show a significant difference across the occupation categories. Blue-collar workers showed significantly lower MSA participation than white-collar and pink-collar workers (male, p=0.006; female, p=0.004; by ANCOVA). High sedentary behavior was significantly associated with white-collar occupations (p<0.001 by ANCOVA). Longer working hours were negatively associated with MVPA (OR=1.01; CI 1.01-1.02) and MSA (OR=1.01; CI 1.00-1.02). Workers with higher stress were less likely to participate in MSA (male: OR=1.43; CI 1.10-1.86; female: OR=1.39; CI 1.08-1.80). Self-employed workers showed lower MVPA levels than employees (male: OR=1.26; CI 1.09-1.47; female: OR=1.36; CI 1.13-1.64). Daily workers compared to full-time workers (OR=0.38; CI 0.24-0.59) and temporary workers compared to regular workers (OR=0.75; CI 0.59-0.95) were associated with less sedentary behavior in men…"

In the "Materials and methods – Data collection and participants" section,

"…Participants were missing data on PA (n=24); education level (n=1); income level (n=8); work time (n=11); working schedule (n=10); occupation category (n=7); and perception of stress (n=11)…"

⇒"…Participants were missing data on PA (n=24); education level (n=1); income level (n=8); work time (n=11); working schedule (n=10); occupation category (n=7); working status/employment type/employment status (n=2); and perception of stress (n=11)..."

In the "Materials and methods – Demographic and work-related variables" section,

Work-related factors included average work time per week, working schedule ("daytime worker" or "shift worker"), occupation category ("white-collar", "pink-collar", or "blue-collar"), and level of stress perception ("low" or "high").

⇒ "…Work-related factors included average work time per week, working schedule ("daytime worker" or "shift worker"), occupation category ("white-collar", "pink-collar", or "blue-collar"), working status ("employee", "self-employed", or "unpaid family worker"), employment type ("full-time", "part-time", or "daily worker"), employment status ("regular" or "temporary"), and level of stress perception ("low" or "high")…"

In the "Result – Differences in sociodemographic and work-related factors by PA guideline compliance and level of sedentary behavior" section,

"…Stress perception was significantly associated with MSA and sedentary behavior in both sexes, and working schedule with sedentary behavior in female. Sedentary behavior was significantly associated with working status, employment type and status in both sexes…"

⇒"…Stress perception was significantly associated with MSA and sedentary behavior in both sexes, and working schedule with sedentary behavior in female. Working status was significantly associated with MVPA in both sexes, employment type with MVPA and MSA, and employment status with MSA in male. Sedentary behavior was significantly associated with working status, employment type and status in both sexes…"

In the "Result – Factors affecting compliance to PA guidelines" section,

"…Workers not meeting the MVPA guideline worked longer hours than those who met the guideline (OR=1.01; CI 1.01–1.02)…"

⇒"…Workers not meeting the MVPA guideline worked longer hours than those who met the guideline (OR=1.01; CI 1.01–1.02). Self-employed workers of both sexes (males: OR=1.26; CI 1.09-1.47; females: OR=1.36; CI 1.13-1.64) and female unpaid family workers (OR=1.35; CI 1.02-1.78) were at a higher risk of not meeting the MVPA guideline…"

In the "Result – Factors affecting high sedentary behavior" section,

"…White-collar workers were at a greater risk of high sedentary behavior compared to pink- and blue-collar workers (OR=0.40; CI 0.28–0.59 for male pink-collar workers; OR=0.34; CI 0.27–0.44 for male blue-collar workers; OR=0.23; CI 0.18–0.30 for female pink-collar workers; OR=0.37; CI 0.28–0.48 for female blue-collar workers)…"

⇒"…White-collar workers were at a greater risk of high sedentary behavior compared to pink- and blue-collar workers (OR=0.40; CI 0.28–0.59 for male pink-collar workers; OR=0.34; CI 0.27–0.44 for male blue-collar workers; OR=0.23; CI 0.18–0.30 for female pink-collar workers; OR=0.37; CI 0.28–0.48 for female blue-collar workers). Male daily workers compared to full-time workers (OR=0.38; CI 0.24–0.59) and male temporary workers compared to regular workers (OR=0.75; CI 0.59-0.95) were less likely to show high sedentary behavior…"

We added the 7th paragraph of the discussion section.

"Working status (employee/self-employed/unpaid family worker) was significantly associated with workers' MVPA level. Self-employed workers compared to employees showed significantly lower participation in MVPA. There are two contradictory views on the

health of self-employed workers.[40 41] One is that as self-employed workers have the authority regarding their jobs, they demonstrate better health behaviors (e.g. physical activity, smoking). However, the other perspective exists that they are likely to be in poor health due to high levels of job demand and work intensity. Korea, in particular, has the 7th highest proportion of self-employed workers in the working population among the thirty-five OECD countries, and small-sized (less than 50 workers) businesses, which have poorer working conditions than larger enterprises,[42] occupy more than half of the total businesses.[43 44] These negative association of self-employment and health behavior would partly explain our result that self-employed workers demonstrated significantly lower PA levels. Employment status (full-time/part-time/daily workers, regular/temporary) also showed a significant association with sedentary behaviors. In men, full-time workers compared to daily workers, and regular workers compared to temporary workers engaged in sedentary behavior for significantly longer time. Female workers also showed similar patterns, but lost the statistical significance in the fully-adjusted model."

Comment 3:
The process of defining physical activity from questionnaire data seems not clear to us. The results from dichotomous use (i.e., meeting or not meeting the guideline of MVPA and MSA, high vs low sedentary) also have limited interpretation/usefulness.

Response:
We explained the process of defining physical activity from questionnaire data in more detail in the method section. Although the cut-off point was determined based on the WHO physical activity recommendations and the meta-analysis, we acknowledge the limitations of using dichotomous variables. Therefore, we also analyzed the data as continuous variables in Table 5.

In the "Materials and methods – Physical activity assessment-MVPA" section,

"…The information on MVPA level was collected in three domains: occupational PA (OPA), transportation PA (TPA), and leisure time PA (LTPA).[25]…"

⇒"…The MVPA refers to the PA performed at over 3 METs (MET, Metabolic equivalent of task; 3 METs, three times the intensity of rest). The information on MVPA level was collected in three domains: occupational PA (OPA), transportation PA (TPA), and leisure time PA (LTPA).[25] The OPA refers to PA undertaken during paid or voluntary work including studying and household chores. The TPA refers to PA performed to get places such as walking or cycling. The LTPA is defined as PA that is not required as an essential activity of daily living such as sports, fitness, and recreational activities…"

In the "Materials and methods – Physical activity assessment-MVPA" section,

"…For OPA and LTPA, moderate-intensity PA (MPA) and VPA were asked separately, and for TPA, only MPA was asked…"

⇒"…For OPA and LTPA, moderate-intensity PA (MPA) and VPA were asked separately, and for TPA, only MPA was asked. The VPA refers to activities that require hard physical effort and cause large increases in breathing or heart rate (PA performed at 6 or more METs),

whereas the MPA refers to activities that require moderate physical effort and cause small increases in breathing or heart rate (PA performed between 3 and <6 METs)…"

Comment 4:
We also would've liked to see the distribution of leisure vs workplace physical activity by type of job (in the methods they mention collecting this stratified PA info, but we didn't see it reported).

Response:
We had additional data regarding the leisure-time, occupational, and transportation physical activity. We assessed the distribution of each physical activity domain by occupational categories, and added the result in the revised manuscript. We also presented the result as "figure 1".

In the "Result – Estimated time spent on MVPA, MSA and sedentary behavior by occupation category, adjusted by sociodemographic factors" section,

"…In both sexes, the total estimated time spent on MVPA did not differ by occupation categories…"

⇒"…In both sexes, the total estimated time spent on MVPA did not differ by occupation categories. However, time spent in the occupational domain of MVPA (OPA) was significantly longer in male blue-collar workers than in other occupation categories in men ($p<0.001$), and time spent in the transportation domain of MVPA (TPA) was significantly longer in female blue-collar workers than pink-collar workers ($p=0.018$) …"

In the 3rd paragraph of the discussion section,

"…This was because, although the level of LTPA in blue-collar workers was lower than in white-collar workers, much higher levels of OPA in blue-collar workers resulted in higher total MVPA.[16 19] Along with technical evolution in industry, work-related physical exertion has been declining rapidly, and OPA contributed less to total MVPA than before.[29]…"

⇒"…This was because, although the level of LTPA in blue-collar workers was lower than in white-collar workers, much higher levels of OPA in blue-collar workers resulted in higher total MVPA.[16 19] This is inconsistent with our findings that there was no significant difference in the total MVPA and LTPA among occupation categories. In our study, male blue-collar workers did show significantly higher OPA than other occupation categories, but after summing TPA and LTPA, their MVPA levels did not significantly differ from other occupation categories. Along with technical evolution in industry, work-related physical exertion has been declining rapidly, and OPA contributed less to total MVPA than before.[29] Especially, in female workers, OPA accounted for a less significant portion, whereas TPA was the major contributor to total MVPA…"

We added "figure 1".

Figure 1. Comparisons of estimated time spent in MVPA (A), MSA (B) and sedentary behavior (C) adjusted by age, education level, residential area, and income level according to

the type of occupation and sex in middle-aged workers in Korea. (A) For OPA, male blue-collar workers^{B} are significantly different from the white-A and pink-collar workers^{A}. For TPA, female blue-collar workers^{b} are significantly different from female pink-collar workers^{a}. (B) Male pink-collar workers^{A} are significantly different from male blue-collar workers^{B}. Female white-collar workers^{a} are significantly different from female blue-collar workers^{b}. (C) White-collar workers^{Aa} are significantly different from pink-collar and blue-collar workers^{Bb} in both sexes. Error bars indicate 95% confidence intervals. MVPA, moderate-to-vigorous physical activity; OPA, occupational physical activity; TPA, transportation physical activity; LTPA, leisure-time physical activity; MSA, muscle-strengthening activities.

Comment 5:
It is not clear to us why there were no findings involving a few explanatory variables including occupational category in Table 3 and 4.

Response:
Variables that were not significant in Tables 1 and 2 were not included in Table 3 and 4. That is the reason why some of the variables are missing in Tables 3 and 4.

Comment 6:
SAS has PROC SURVEY procedure for complex weighting and Korea CDC recommends its use for KNHANES data analysis, although SUDAAN can also be used. The authors should have reported which they used.

Response:
In the statistical analysis, SAS PROC SURVEY was used. We reported this in the method section.

In the "Materials and methods – Statistical analysis" section,

"…The analyses were performed using SAS version 9.4 (SAS Institute, Inc., Cary, NC, USA), and p-values <0.05 were considered statistically significant…"

⇒"…The analyses were performed using SAS version 9.4 (SAS Institute, Inc., Cary, NC, USA), and SAS PROC SURVEY was used for complex weighting. P-values <0.05 were considered statistically significant…"

BMJ Open

The association of occupation with the daily physical activity and sedentary behavior of middle-aged workers in Korea: a cross-sectional study based on data from the Korea National Health and Nutrition Examination Survey

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Original research

The association of occupation with the daily physical activity and sedentary behavior of middle-aged workers in Korea: a cross-sectional study based on data from the Korea National Health and Nutrition Examination Survey

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ABSTRACT

Objectives

The World Health Organization (WHO) recommends that adults engage in regular moderate-to-vigorous-intensity physical activity (MVPA), muscle-strengthening activities (MSA), and minimize sedentary behavior. This study aimed to determine the association of occupation with MVPA, MSA, and sedentary behavior in middle-aged Korean workers.

Design and setting

A cross-sectional study using data from the 7th Korea National Health and Nutrition Examination Survey (KNHANES, 2016–2018).

Participants

Workers aged between 40-69 years in Korea (n=6,359).

Outcome measures

Population-weighted proportions not meeting the MVPA (< 150 min/week) and MSA (< 2 days/week) guidelines, and with high sedentary behavior (> 7 hours/day) were calculated, and their associations with sociodemographic and work-related variables were assessed using multiple logistic regression analyses. Additionally, the estimated time spent on MVPA, MSA and sedentary behavior according to the occupation categories (white-, pink-, blue-collar) was calculated using analysis of covariance (ANCOVA).

Results

The MVPA level did not show a significant difference across the occupation categories. Blue-collar workers showed significantly lower MSA participation than white-collar and pink-collar workers (male, p=0.006; female, p=0.004; by ANCOVA). High sedentary behavior was significantly associated with white-collar occupations (p<0.001 by ANCOVA). Longer working hours were negatively associated with MVPA (OR=1.01; CI 1.01-1.02) and

MSA (OR=1.01; CI 1.00-1.02). Workers with higher stress were less likely to participate in MSA (male: OR=1.43; CI 1.10-1.86; female: OR=1.39; CI 1.08-1.80). Self-employed workers showed lower MVPA levels than employees (male: OR=1.26; CI 1.09-1.47; female: OR=1.36; CI 1.13-1.64). Daily workers compared to full-time workers (OR=0.38; CI 0.24-0.59) and temporary workers compared to regular workers (OR=0.75; CI 0.59-0.95) were associated with less sedentary behavior in men.

Conclusion

A number of work-related factors were associated with PA levels and sedentary behavior in middle-aged workers. The workplace is one of the critical elements to intervene in health promotion strategies.

Strengths and limitations of this study

- This is the first study in Korea to investigate the MVPA and MSA participation and sedentary behavior concurrently across occupation categories using national representative data.

- This study comprehensively investigated the association of occupation with PA level and sedentary behavior regarding various socioeconomic confounding factors.

- This study assessed the MVPA level of three domains (occupational, transportation, and leisure time) and sedentary behavior together to estimate overall PA status accurately.

- The MVPA level, MSA level, and degree of sedentary behavior were analyzed not only as dichotomous variables ("meeting the MVPA or MSA guideline" or "not meeting the MVPA or MSA guideline, "high sedentary" or "low sedentary") but also as continuous variables (time spent on MVPA, MSA, and sedentary behavior).

- Since the study design was cross-sectional, causality cannot be inferred.

INTRODUCTION

Physical inactivity is a worldwide public health problem and is responsible for about 6%-10% of the global burden of major chronic non-communicable diseases.[1] Until recently, physical activity (PA) recommendations primarily focused on moderate-to-vigorous-intensity physical activity (MVPA).[2] However, based on recent evidence, World Health Organization's (WHO) PA guidelines for public health now include muscle-strengthening activities (MSA) in addition to MVPA.[3] MSA provides additional metabolic health benefits[4] and prevents sarcopenia.[5] Moreover, there are cumulative health benefits by combining MVPA and MSA.[6] [7] Meeting guidelines for both activities compared to meeting the guideline for only one was associated with a lower risk of all-cause mortality in cohort studies.[8]

In addition, sedentary behavior has recently emerged as a potential independent risk factor distinct from insufficient PA for poor health.[9] The WHO guidelines state that the amount of time spent in sedentary should be limited and replaced with PA of any intensity. Previous large cohort studies have shown the detrimental effects of sedentary behavior on all-cause mortality,[10] metabolic syndrome, cardiovascular disease,[10 11] and mental health.[12] The association between prolonged sitting and adverse health outcomes remained significant even after adjusting for aerobic exercise time, indicating that people should be active daily and limit their sedentary time for optimal health benefits.[9 10 13]

Among the various socioeconomic factors related to PA, one of the prime determinants might be occupation. People spend most of their lives employed, and occupation largely influences people's activities, not only during work hours but also during their leisure time. Some studies have focused on assessing PA levels in association with occupation using representative national data.[14-21] However, most of the earlier studies did not focus concurrently on types of PA, such as MVPA and MSA, and sedentary behaviors, and analyses were limited to either work time or leisure time.[14-17 21] Each domain of MVPA might

have different implications on health, as increasing evidence shows that OPA and LTPA have contrasting health effects, so-called PA health paradox.[22] Therefore, this study aimed to investigate the middle-aged workers' overall participation in MVPA, MSA, and sedentary behavior according to sociodemographic and work-related factors. The MVPA level was investigated not only in total but also by each domain (i.e. occupational, transportation, and leisure time).

MATERIALS AND METHODS

Data collection and participants

This study was based on data from the 7th Korea National Health and Nutrition Examination Survey (KNHANES, 2016–2018). The KNHANES is a nationwide, multistage-stratified, and complex design survey on the health and nutrition of a representative sample of the entire population of the Republic of Korea (hereafter Korea). It is conducted annually by trained specialists under the supervision of the Korea Centers for Disease Control and Prevention (KCDC). Data from the health questionnaire survey are collected using self-reported questionnaires. Of the 24,269 participants in the 2016–2018 survey, 10,586 adults aged between 40 and 70 years were initially selected. Participants who were students or unemployed or who had responded that PA in their daily lives was limited due to physical or mental disorders were excluded. Finally, 6,359 participants were included in this study. Participants were missing data on PA (n=24); education level (n=1); income level (n=8); work time (n=11); working schedule (n=10); occupation category (n=7); working status/employment type/employment status (n=2); perception of stress (n=11); and source of stress (n=3).

Data collection was performed after approval by the Institutional Review Board (IRB) of the KCDC (approval number: 2018-01-03-P-A). The details of the survey and dataset used in this

study are available in a public, open access KNHANES repository[23] (https://knhanes.kdca.go.kr/knhanes/sub03/sub03_02_05.do).

Physical activity assessment

The study collected information on participants' PA levels composed of MVPA and MSA. PA levels were measured using the Korean version of the modified global physical activity questionnaire (K–GPAQ). The GPAQ was developed by the WHO for PA surveillance in countries and has acceptable reliability and validity.[24 25] The GPAQ was translated into a Korean version in 2013, which has established reliability and validity (Kappa, 0.416–0.669; Spearman's rho, 0.642–0.762).[26]

MVPA

The MVPA refers to the PA performed at over 3 METs (MET, Metabolic equivalent of task; 3 METs, three times the intensity of rest). The information on MVPA level was collected in three domains: occupational PA (OPA), transportation PA (TPA), and leisure time PA (LTPA).[27] The OPA refers to PA undertaken during paid or voluntary work including studying and household chores. The TPA refers to PA performed to get places such as walking or cycling. The LTPA is defined as PA that is not required as an essential activity of daily living such as sports, fitness, and recreational activities. The total MVPA level refers to the sum of OPA, TPA, and LTPA. Respondents reported their MVPA frequency (days) and duration (hours and minutes) in a typical week and were asked to report only activities that lasted for at least 10 continuous minutes. The PA level for each activity domain was estimated by multiplying the frequency by the duration. When summing the values, the minutes spent on vigorous-intensity PA (VPA) were multiplied by two. For OPA and LTPA, moderate-intensity PA (MPA) and VPA were asked separately, and for TPA, only MPA was

asked. The VPA refers to activities that require hard physical effort and cause large increases in breathing or heart rate (PA performed at 6 or more METs), whereas the MPA refers to activities that require moderate physical effort and cause small increases in breathing or heart rate (PA performed between 3 and <6 METs). Example cards showing the typical activities for each question were used to help the respondents understand the questions for consistent and valid measurements.

MSA

To assess MSA, respondents were asked, "Over the past 7 days, how many days did you do any physical activities specifically designed to strengthen your muscles such as sit-ups, push-ups, lifting weights or dumbbells?".

Compliance with PA guidelines

The 2010 WHO "Global recommendations on physical activity for health" recommends that adults aged 18–64 years old and 65 years old and above engage in: (1) ≥150 min/week of MPA, ≥75 min/week of VPA or an equivalent combination of both; and (2) MSA at a moderate or greater intensity that involves all major muscle groups on two or more days a week. The study's participants were dichotomized as either "meeting the guideline" or "not meeting the guideline" depending on their adherence to each type of PA (MVPA and MSA).

Sedentary behaviors

Sedentary behaviors are defined as behaviors with low energy expenditure (≤1.5 METs), and are distinct from the simple absence of PA.[27] The amount of sedentary behavior was measured using the item in the K-GPAQ. Respondents reported their average time spent on sedentary behavior per day during a typical week. Sedentary behavior was defined as sitting

or lying down while working, at home, moving from place to place, and during leisure activities excluding sleep. We defined sedentary behavior exceeding seven hours a day as "high sedentary", based on a meta-analysis showing an increased risk of all-cause mortality around seven to eight hours a day of sedentary time.[28]

Demographic and work-related variables

We analyzed the subjects' adherence to PA guidelines based on sociodemographic and work-related factors. The sociodemographic variables included age, sex, and education level ("below middle school graduate," "high school graduate," or "college graduate or higher"), location of residence ("urban" or "rural"), family structures ("single-person household" or "with members"), and quartiles of household income. Work-related factors included average work time per week, working schedule ("daytime worker" or "shift worker"), occupation category ("white-collar", "pink-collar", or "blue-collar"), working status ("employee", "self-employed", or "unpaid family worker"), employment type ("full-time", "part-time", or "daily worker"), employment status ("regular" or "temporary"), level of stress perception-1 ("low" or "high"), and level of stress perception-2 ("low" or "high-job related" or "high-other") . As for work-related variables, we collected the data based on the information about participants' "current" occupations. In the survey, occupation was classified into ten categories (manager, professionals and related worker, office worker, service worker, sales worker, agriculture/forestry/fishery, craft and related trades workers, machine operators and assemblers, labor workers, and soldier) according to the Korean standard classification of occupation (KSCO).[29] We further grouped types of occupation as white-collar (manager, professionals and related worker, office worker), pink-collar (service worker, sales worker), and blue-collar (agriculture/forestry/fishery, craft and related trades workers, machine operators and assemblers, labor workers, soldier). "Stress perception" was assessed as "high"

when participants responded that they experienced “very much” or “much” stress. “Stress perception” measured overall stress regardless of stress sources. The 2018 KNHANES survey included another variable “source of stress” composed of 9 types of stress sources (i.e. economic problem, job stress, family, spouse, living environment, unemployment, health, family’s health, and etc.). The second “stress perception” variable (stress perception-2) was made by categorization of “high-job related”, “high-other”, and “low” based on whether the stress came from job stress or not in participants with “very much” or ‘much” stress.

Statistical analysis

All the statistical analyses were conducted with a complex sample analysis using weights according to the KCDC’s guidelines for using KNHANES’ raw data. The population-weighted numbers and estimated percentages of the "not meeting the guideline” groups for MVPA and MSA, and the “high sedentary” group were calculated. The Rao-Scott chi-square test for categorical variables and the complex sample general linear model for continuous variables were used to test the differences between the proportions by sociodemographic factors and work-related factors. Multiple logistic regression was used to examine the odds of not meeting the MVPA guideline, not meeting the MSA guideline, and high sedentary behavior. First, we performed the analysis by adjusting for age and each related factor (Model 1). Next, we performed an additional analysis by adjusting the variables that were statistically significant in Model 1 (Model 2). Before analysis, we assessed collinearity among all covariates we used in the analysis, using tests for variance inflation factor (VIF), with a VIF≥5 indicating multicollinearity. The VIFs ranged from 1.019-1.938, indicating no evidence of collinearity. Analysis of covariance was used to compare the time spent on MVPA, MSA, and sedentary behavior, adjusted by sociodemographic variables that were significant in the previous analysis. The analyses were performed using SAS version 9.4

(SAS Institute, Inc., Cary, NC, USA), and SAS PROC SURVEY was used for complex weighting. P-values <0.05 were considered statistically significant.

Patients and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

RESULTS

Proportions of participants in the "Not meeting WHO PA Guidelines" and "High Sedentary" groups

Among male workers, the proportion of participants who did not meet the guidelines was 55.0% for MVPA and 73.5% for MSA; among female workers, the proportions were 59.4% for MVPA and 86.5% for MSA. The proportions for high sedentary group was 51.3% in male workers and 44.4% in female workers.

Differences in sociodemographic and work-related factors by PA guideline compliance and level of sedentary behavior

Unweighted numbers and population-weighted estimated percentages overall within each sociodemographic and work-related variable category in Korean middle-aged workers are shown in supplementary Table 1. Unadjusted analyses indicated significant differences in a number of sociodemographic and work-related factors depending on adherence to the PA guidelines (Table 1 and Table 2). The education level, residential area, and household income were significantly associated with MVPA in male, and MSA and sedentary behavior in both sexes. Only residential area was associated with MVPA in female. Working hours was significantly associated with MVPA, MSA in both sexes and sedentary behavior in female.

Occupation category was significantly associated with MVPA, MSA, and sedentary behavior. Stress perception was significantly associated with MSA and sedentary behavior in both sexes, and working schedule with sedentary behavior in female. Working status was significantly associated with MVPA in both sexes, employment type with MVPA and MSA, and employment status with MSA in male. Sedentary behavior was significantly associated with working status, employment type and status in both sexes.

Factors affecting compliance to PA guidelines

The risk factors for "not meeting the MVPA guideline" and "not meeting the MSA guideline" in middle-aged workers were investigated (Table 3 and Table 4). Men who had been educated up to middle school (OR=2.19; CI 1.80–2.67) and high school graduates (OR=1.30; CI 1.10–1.51) had a higher risk of not adhering to the MVPA guideline compared to those who had college degrees. Rural residents were less likely to meet the MVPA guideline than urban residents in both sexes (males: OR=1.27; CI 1.06–1.53; females: OR=1.74; CI 1.41–2.14). Workers not meeting the MVPA guideline worked longer hours than those who met the guideline (OR=1.01; CI 1.01–1.02). Self-employed workers of both sexes (males: OR=1.26; CI 1.09-1.47; females: OR=1.36; CI 1.13-1.64) and female unpaid family workers (OR=1.35; CI 1.02-1.78) were at a higher risk of not meeting the MVPA guideline.

Men who had been educated up to middle school were less likely to meet the MSA guideline than those who had college degrees (OR=1.94; CI 1.31–2.87). Rural residents were less likely to meet the MSA guideline than urban residents (males: OR=1.43; CI 1.04–1.96; females: OR=1.65; CI 1.20–2.27). Males in the lowest income quartile were less likely to meet the MSA guideline than those in the highest quartile (OR=1.77; CI 1.26–2.48). Workers not meeting the MSA guideline worked longer hours than those who met the guideline (OR=1.01; CI 1.00–1.02). Female blue-collar workers were at a higher risk of not meeting

the MSA guideline compared to white-collar workers (OR=1.71; CI 1.30–2.24). Workers with higher stress were unlikely to practice the MSA guideline than those with lower stress (males: OR=1.43; CI 1.10–1.86; females: OR=1.39; CI 1.08–1.80).

Factors affecting high sedentary behavior

The risk factors for high sedentary behavior are shown in Table 3 and Table 4. Male high school graduates were less likely to show high sedentary behavior than those with college degrees (OR=0.69; CI 0.55–0.88). Male rural residents were at a lower risk of high sedentary behavior (OR=0.57; CI 0.43–0.74). White-collar workers were at a greater risk of high sedentary behavior compared to pink- and blue-collar workers (OR=0.40; CI 0.28–0.59 for male pink-collar workers; OR=0.34; CI 0.27–0.44 for male blue-collar workers; OR=0.23; CI 0.18–0.30 for female pink-collar workers; OR=0.37; CI 0.28–0.48 for female blue-collar workers). Male daily workers compared to full-time workers (OR=0.38; CI 0.24–0.59) and male temporary workers compared to regular workers (OR=0.75; CI 0.59-0.95) were less likely to show high sedentary behavior.

Estimated time spent on MVPA, MSA and sedentary behavior by occupation category, adjusted by sociodemographic factors

The time spent on MVPA, MSA, and sedentary behavior, adjusted by age, education level, residential area, and income level were compared across occupation categories (Table 5 and figure 1). In both sexes, the total estimated time spent on MVPA did not differ by occupation categories. However, time spent in the occupational domain of MVPA (OPA) was significantly longer in male blue-collar workers than workers in other occupation categories in men ($p<0.001$), and time spent in the transportation domain of MVPA (TPA) was significantly longer in female blue-collar workers than pink-collar workers ($p=0.018$). Male

pink-collar workers (p=0.006) and female white-collar workers (p=0.004) spent significantly more times in MSA than blue-collar workers. White-collar workers showed significantly more sedentary behavior than pink- and blue-collar workers in both sexes (p<0.001).

Estimated time spent on MVPA domains according to the sedentary behavior, adjusted by sociodemographic factors

The time spent on each domain of MVPA was compared between "low sedentary" and "high sedentary" group. "Low sedentary" group spent significantly longer time on OPA (males: p<0.001; females: p=0.018) and TPA (p<0.001) than "high sedentary" group in both sexes (supplementary Table 2).

DISCUSSION

This study assessed Korean middle-aged workers' compliance with PA guidelines and the degree of the sedentary behavior in association with sociodemographic and work-related variables, particularly focusing on the influence of the occupation category. More than half of the middle-aged workers did not meet the minimum recommended level of MVPA in both sexes. The MSA compliance rate was far less than that for MVPA, especially in women, which was about half the compliance rate in men. The average time for sedentary behavior was longer in men than in women. Compared to workers with high sedentary behavior, workers with low sedentary behavior spent their additional active time on OPA and TPA instead of LTPA.

The association between occupation category and total MVPA was investigated. While many previous studies focused exclusively on LTPA, this study assessed the total MVPA level to evaluate the overall MVPA status. Results showed that the differences in MVPA levels across the occupation categories became insignificant after adjusting for

sociodemographic factors. This implies that sociodemographic factors are more important predictors of MVPA participation than occupation category. As occupation is closely intertwined with socioeconomic status, studying the association between occupation category and PA is complex and it is important to consider the confounding effects of socioeconomic factors.[30]

Previous studies have shown that white-collar workers have more LTPA than blue-collar workers.[14 15 17-19] However, the total MVPA level was higher in blue-collar workers than in white-collar workers in all ten studies included in a systematic review analysis.[15] This was because, although the level of LTPA in blue-collar workers was lower than in white-collar workers, much higher levels of OPA in blue-collar workers resulted in higher total MVPA.[16 19] This is inconsistent with our findings that there was no significant difference in the total MVPA and LTPA among occupation categories. In our study, male blue-collar workers did show significantly higher OPA than workers in other occupation categories, but their total MVPA levels did not significantly differ from workers in other occupations. Along with technical evolution in industry, work-related physical exertion has been declining rapidly, and OPA contributed less to total MVPA than before.[31] Especially, in female workers, OPA accounted for a less significant portion, whereas TPA was the major contributor to total MVPA. While LTPA is consistently associated with positive health benefits in previous research,[32] OPA remains controversial,[33] with some studies even found that high OPA was associated with increased cardiovascular disease risk.[22 34] Therefore, regarding MVPA, LTPA should primarily be emphasized as a public health promotion strategy irrespective of occupation. Also, since some male blue-collar workers are still exposed to high OPA, excessive OPA should be avoided for those with cardiovascular risk factors at the workplace.

The blue-collar occupations were associated with significantly lower participation in MSA compared to white-collar or pink-collar occupations. Although a limited number of studies

assessed MSA participation in relation to occupation category, our findings are consistent with prior studies.[14 35] It should be noted that there are some differences in the questionnaire items among the different types of MSA assessment tools.[36] The survey item we used in our study (How many days did you do any physical activities specifically designed to strengthen your muscles such as sit-ups, push-ups, lifting weights or dumbbells?) is likely to have only assessed MSA performed during leisure time. The MSA during work time (e.g., moving heavy items, digging, construction work), on the other hand, might not have been counted when calculating the MSA level. This would have underestimated the actual level of MSA in blue-collar workers who might have accumulated some extent of MSA while working. Theoretically, attaining MSA within the occupational domain is possible and some occupational activities are associated with both MVPA and MSA.[37] However, in order to obtain optimal health benefits, MSA should be performed with adequate intensity and sufficient duration using all major muscle groups, which is only possible during leisure time.

White-collar workers had the longest sedentary time among occupation categories. Excessive sitting and insufficient PA during working hours have increasingly been recognized as a public health problem. Recent accelerometry-based studies showed that occupation categories of "office and administrative support", "architecture/engineering", and "computer/mathematical", which are all white-collar occupations, were among the least favorable type of job when overall activities were assessed by accelerometry.[20 38] Therefore, workplace PA interventions such as using sit-stand desks, and more break times to attend workplace exercise programs should be implemented as a public health promotion strategy, particularly in white-collar workers who have the longest sedentary time.[39]

Work-related factors, including working hours, working schedule, and stress perception were investigated. Those who worked for longer hours reported lower levels of participation in both MVPA and MSA than those who worked fewer hours. The role of working hours is

especially important as the working hours reported by Korean adults are one of the longest among the member states of the Organization for Economic Co-operation and Development (OECD).[40] Previous evidence has indicated that working hours have a negative threshold effect on participation in MVPA, which means that the negative correlation between working hours and MVPA level becomes evident at the 45–50 hours/week level and above.[15] Shift work, compared to daytime work, did not show any association with PA level or sedentary behavior similar to previous findings.[19] This might be due to the heterogeneity present in different types of shift work (e.g. shifts with or without night work, shifts with or without rotation, etc.). Additionally, those who have higher overall stress participated less in MSA. Higher job strain had been shown to be associated with low PA levels in previous studies,[15 41] which is inconsistent with our finding that 'higher job stress' group did not show significant difference in PA participation compared with 'high stress from other sources' group and 'low stress' group. Consequently, reducing working hours and helping workers manage excessive stress regardless of stress sources are important to encourage workers to be physically active.

Working status (employee/self-employed/unpaid family worker) was significantly associated with workers' MVPA level. Self-employed workers compared to employees showed significantly lower participation in MVPA. There are two contradictory views on the health of self-employed workers.[42 43] One is that as self-employed workers have the authority regarding their jobs, they demonstrate better health behaviors (e.g. physical activity, smoking). However, the other perspective exists that they are likely to be in poor health due to high levels of job demand and work intensity. Korea, in particular, has the 7th highest proportion of self-employed workers in the working population among the thirty-five OECD countries, and small-sized (less than 50 workers) businesses, which have poorer working conditions than larger enterprises,[44] occupy more than half of the total businesses.[45 46] These

negative association of self-employment and health behavior would partly explain our result that self-employed workers demonstrated significantly lower PA levels. Employment status (full-time/part-time/daily workers, regular/temporary) also showed a significant association with sedentary behaviors. In men, full-time workers compared to daily workers, and regular workers compared to temporary workers engaged in sedentary behavior for significantly longer time. Female workers also showed similar patterns, but lost the statistical significance in the fully-adjusted model.

Strengths and limitations

The strength of our study is that we investigated the MVPA and MSA participation and sedentary behavior concurrently across occupation categories using national representative data. We assessed total MVPA level and sedentary behavior together to estimate overall PA status in middle-aged workers. Our results demonstrated the different PA patterns of middle-aged workers depending on the occupational factors, which would help develop worksite targeted intervention. Another strength is that we took into account various sociodemographic variables during the analysis, thereby provides more adequate presentation of the association between occupation and PA levels. However, our study also has several limitations. Self-report measurement of MVPA, MSA, and sedentary behavior might have recall bias. Under or over-reporting due to social desirability is possible. However, this limitation might not significantly bias our results because the KNHANES uses standardized self-report instruments for public health surveillance and the recruited subject numbers were sufficient to decrease bias. The second limitation is that the inferences of causality could not have been determined because of the cross-sectional study design. Last, the data we used were limited to middle-aged individuals. However, previous studies have shown that sociodemographic correlates of PA participation change with the age of the studied population.[47] Therefore, we

selected the middle-aged population for a more homogenous sample of the population. Moreover, as the middle-aged population is a critical age group for the prevention of multiple chronic health conditions, our findings would help to inform health promotion policies for the targeted population.

CONCLUSION

In conclusion, work-related factors, especially occupation category, were significantly associated with MVPA, MSA, and sedentary behavior in middle-aged workers. The workplace would offer a worthy setting for targeted interventions. As blue-collar workers are at risk of engaging in lower MSA, providing education and building facilities for MSA at work would be helpful. Work-site intervention to provide intermittent breaks to prolonged sitting is necessary for white-collar workers. Concerning MVPA, LTPA should be primarily emphasized across all occupation categories. Moreover, knowledge about work-related risk factors for physical inactivity to identify vulnerable subpopulations would help establish public health policies to reduce health inequalities.

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Contributors

Joo Hye Sung conceived of the study design and wrote substantial parts of the manuscript. Se Rhim Son contributed substantively to the data analysis. Seol-Hee Baek was responsible for quality assurance of the data and interpretation of these findings. Byung-Jo Kim conceived of and supervised the study, and contributed integrating key aspects of the study.

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Competing interests

None declared.

Patient consent for publication

Not required.

Ethics approval

Data collection was performed after approval by the Institutional Review Board (IRB) of the Korean Centers for Disease Control and Prevention (approval number: 2018-01-03-P-A).

Data sharing statement

The dataset used in this study are available in a public, open access KNHANES repository. (https://knhanes.kdca.go.kr/knhanes/sub03/sub03_02_05.do.).

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Figure legends

Figure 1. Comparisons of estimated time spent in MVPA (A), MSA (B) and sedentary behavior (C) adjusted by age, education level, residential area, and income level according to the type of occupation and sex in middle-aged workers in Korea. (A) For OPA, male blue-collar workers^{B} are significantly different from the white-^{A} and pink-collar workers^{A}. For TPA, female blue-collar workers^{b} are significantly different from female pink-collar workers^{a}. (B) Male pink-collar workers^{A} are significantly different from male blue-collar workers^{B}. Female white-collar workers^{a} are significantly different from female blue-collar workers^{b}. (C) White-collar workers^{Aa} are significantly different from pink-collar and blue-collar workers^{Bb} in both sexes. Error bars indicate 95% confidence intervals. MVPA, moderate-to-vigorous physical activity; OPA, occupational physical activity; TPA, transportation physical activity; LTPA, leisure-time physical activity; MSA, muscle-strengthening activities.

Table 1. Population-weighted proportions of participants not meeting "moderate to vigorous-intensity physical activity (MVPA) guideline", not meeting "muscle-strengthening activity (MSA) guideline", and with "high sedentary behavior" by sociodemographic and work-related factors in middle-aged male workers.

	Not meeting MVPA guideline† %(95% CI)*	P value ¶	Not meeting MSA guideline‡ %(95% CI)*	P value ¶	High sedentary§ (>7 hours) %(95% CI)*	P value ¶
Total	55.0(53.0-57.0)		73.5(71.9-76.4)		51.3(49.2-53.4)	
Age	52.2±0.2	0.002	51.6±0.2	0.012	51.1±0.2	<0.001
Education		<0.001		<0.001		<0.001
Below middle school	71.0(66.8-75.2)		84.8(81.6-88.0)		37.1(32.1-42.0)	
High school	57.1(53.7-60.5)		74.4(71.6-77.2)		42.6(39.3-45.8)	
College or higher	48.6(45.8-51.4)		69.4(67.0-71.8)		61.9(59.1-64.6)	
Residence		0.002		0.002		<0.001
Urban	53.7(51.5-55.9)		72.4(70.5-74.2)		54.5(52.1-56.9)	
Rural	62.0(57.2-66.7)		79.7(75.8-83.5)		34.7(29.8-39.5)	
Family structure		0.936		0.703		0.171
Single	54.7(47.8-61.6)		72.4(66.1-78.7)		46.4(39.2-53.6)	
With members	55.0(52.9-57.1)		73.6(71.9-75.4)		51.7(49.4-53.9)	
Income		0.008		<0.001		<0.001
1st(lowest)	59.6(55.2-63.9)		80.5(77.0-84.0)		40.6(36.3-44.9)	
2nd	57.1(53.4-60.8)		74.0(70.9-77.1)		46.6(42.7-50.5)	
3rd	54.4(50.7-58.1)		75.0(71.9-78.0)		54.2(50.5-57.9)	
4th(highest)	50.2(46.4-54.0)		66.5(63.0-70.1)		61.2(57.2-65.2)	
Work time per week	46.6±0.4	<0.001	46.1±0.3	<0.001	45.2±0.4	0.214
Working schedule		0.446		0.485		0.362
Day-time worker	55.4(53.2-57.6)		73.8(72.0-75.6)		51.7(49.4-54.0)	
Shift worker	53.0(47.4-58.6)		71.9(67.1-76.8)		49.0(43.7-54.4)	
Occupation category		<0.001		<0.001		<0.001
White- collar	48.9(46.1-51.7)		69.1(66.5-71.7)		66.1(63.3-68.9)	
Pink-Collar	53.6(48.2-59.0)		67.5(62.6-72.5)		42.1(36.9-47.4)	
Blue- collar	61.8(58.8-64.8)		80.1(77.7-82.5)		38.7(35.6-41.8)	

Working status		<0.001			0.872			0.007
Employee	52.1(49.7-54.6)			73.2(71.0-75.4)			53.3(50.7-56.0)	
Self-employed	59.8(56.7-62.9)			74.2(71.4-77.0)			48.5(44.9-52.1)	
Unpaid family workers	65.0(52.8-77.2)			74.5(60.2-88.8)			34.7(20.8-48.6)	
Employment type		0.002			0.031			<0.001
Full-time	51.1(48.4-53.9)			72.0(69.5-74.4)			58.5(55.7-61.3)	
Part-time	65.7(58.5-72.9)			81.4(75.2-87.7)			34.3(26.8-41.7)	
Daily workers	48.4(39.6-57.2)			77.1(69.6-84.6)			18.0(12.1-23.9)	
Employment status		0.192			0.005			<0.001
Regular	51.0(47.9-54.1)			70.9(68.1-73.8)			61.8(58.7-65.0)	
Temporary	54.3(50.4-58.1)			77.4(74.0-80.7)			37.5(33.7-41.3)	
Stress perception-1		0.266			0.007			<0.001
Low	54.4(52.1-56.7)			72.2(70.3-74.2)			49.2(46.8-51.6)	
High	57.0(53.2-60.8)			78.0(74.7-81.3)			58.2(54.2-62.2)	
Stress perception-2		0.120			0.180			0.259
Low	56.2(52.4-60.1)			71.7(68.1-75.2)			50.2(46.1-54.3)	
High-job related	67.3(57.4-77.2)			77.1(67.3-86.8)			58.9(48.9-69.0)	
High-other	53.4(44.5-62.3)			79.4(71.9-87.0)			52.9(44.4-61.5)	

*Values are presented as population-weighted estimated percentage (95% CI) which are given relative to the total number within each sociodemographic and work-related variable or mean ± standard deviation.

†Proportion of participants not meeting MVPA guideline (< 150 min/week). ‡Proportion of participants not meeting MSA guideline (< 2 days/week). §Proportion of participants with high sedentary behavior (>7 hours/day).

The mean ± standard deviation of two continuous variables for participants who meet the MVPA, MSA guidelines and with low sedentary behavior (≤7 hours/day) are as follows: Age (51.3±0.2 for "meeting MVPA guideline" group; 52.4±0.3 for "meeting MSA guideline" group; 52.6±0.2 for "low sedentary" group), work time per week (44.2±0.4 for "meeting MVPA guideline" group; 43.7±0.5 for "meeting MSA guideline" group; 45.9±0.5 for "low sedentary" group)

¶P-values were derived from Rao-Scott chi-square test for categorical variables and the complex sample general linear model for continuous variables comparing between "not meeting PA guideline" vs "meeting PA guideline" or "high sedentary" vs "low sedentary" groups.

Table 2. Population-weighted proportions of participants not meeting "moderate to vigorous-intensity physical activity (MVPA) guideline", not meeting "muscle-strengthening activity (MSA) guideline", and with "high sedentary behavior" by sociodemographic and work-related factors in middle-aged female workers.

	Not meeting MVPA guideline† %(95% CI)*	P value ¶	Not meeting MSA guideline‡ %(95% CI)*	P value ¶	High sedentary§ (>7 hours) %(95% CI)*	P value ¶
Total	59.4(57.4-61.4)		86.5(85.0-88.0)		44.4(42.2-46.6)	
Age	52.3±0.2	0.085	52.1±0.2	0.548	51.0±0.2	<0.001
Education		0.068		0.013		<0.001
Below middle school	63.5(59.7-67.2)		89.1(86.9-91.3)		33.0(29.2-36.8)	
High school	57.9(54.4-61.3)		86.9(84.7-89.2)		42.9(39.6-46.1)	
College or higher	58.0(54.5-61.5)		84.0(81.3-86.7)		55.3(51.3-59.3)	
Residence		<0.001		0.002		<0.001
Urban	57.5(55.2-59.7)		85.6(83.9-87.2)		46.8(44.3-49.3)	
Rural	69.7(64.9-74.5)		91.6(88.7-94.5)		31.6(26.7-36.4)	
Family structure		0.439		0.438		0.543
Single	56.7(49.6-63.9)		84.8(80.1-89.4)		42.2(35.0-49.5)	
With members	59.6(57.5-61.7)		86.7(85.1-88.2)		44.6(42.2-46.9)	
Income		0.282		0.003		<0.001
1st(lowest)	62.3(58.4-67.0)		90.1(87.6-92.5)		37.9(33.9-41.9)	
2nd	60.0(56.1-63.9)		87.6(85.0-90.2)		44.2(40.3-48.0)	
3rd	57.6(53.8-61.4)		86.5(83.8-89.2)		42.8(38.7-47.0)	
4th(highest)	57.7(53.5-61.9)		82.5(79.1-85.9)		52.6(48.4-56.7)	
Work time per week	39.5±0.5	<0.001	38.3±0.4	0.009	36.9±0.5	0.011
Working schedule		0.456		0.593		0.001
Day-time worker	59.0(56.8-61.3)		86.7(85.1-88.2)		45.9(43.4-48.3)	
Shift worker	61.2(56.1-66.2)		85.7(82.1-89.3)		37.0(32.2-41.9)	
Occupation category		0.007		<0.001		<0.001
White-collar	57.5(54.4-60.6)		83.7(81.2-86.1)		58.9(55.4-62.3)	
Pink-collar	63.9(60.9-67.0)		86.5(84.1-88.9)		34.9(31.3-38.5)	
Blue-collar	56.8(52.6-60.9)		90.7(88.6-92.9)		34.4(30.5-38.4)	

Working status		<0.001		0.113		0.02
Employee	56.3(53.8-58.7)		87.0(85.3-88.7)		45.8(43.2-48.3)	
Self-employed	66.0(61.8-70.1)		84.0(80.7-87.2)		43.8(39.2-48.4)	
Unpaid family workers	68.3(61.6-75.0)		88.8(84.7-92.9)		35.2(28.2-42.1)	
Employment type		0.254		0.309		0.012
Full-time	55.5(52.4-58.5)		86.2(84.1-88.2)		48.5(45.2-51.7)	
Part-time	56.2(51.5-60.8)		88.2(85.1-91.2)		40.4(35.6-45.2)	
Daily worker	62.5(54.8-70.2)		89.7(84.9-94.6)		41.4(33.6-49.2)	
Employment status		0.165		0.665		<0.001
Regular	53.9(49.5-58.2)		86.5(83.8-89.2)		55.5(51.1-59.9)	
Temporary	57.4(54.5-60.3)		87.2(85.2-89.3)		41.1(38.1-44.1)	
Stress perception-1		0.090		0.020		0.029
Low	58.4(56.0-60.7)		85.5(83.8-87.3)		43.0(40.4-45.6)	
High	62.2(58.4-66.0)		89.1(86.7-91.5)		48.5(44.2-52.8)	
Stress perception-2		0.402		0.451		0.465
Low	60.3(56.4-64.3)		84.3(81.4-87.3)		45.6(41.2-50.0)	
High-job related	64.4(53.4-75.5)		89.5(82.5-96.5)		51.5(40.7-62.4)	
High-other	66.3(58.0-74.7)		86.4(80.5-92.3)		50.3(40.4-60.1)	

*Values are presented as population-weighted estimated percentage (95% CI) which are given relative to the total number within each sociodemographic and work-related variable or mean ± standard deviation.

†Proportion of participants not meeting MVPA guideline (< 150 min/week). ‡Proportion of participants not meeting MSA guideline (< 2 days/week). §Proportion of participants with high sedentary behavior (>7 hours/day).

The mean ± standard deviation of two continuous variables for participants who meet the MVPA, MSA guidelines and with low sedentary behavior (≤7 hours/day) are as follows: Age (51.8±0.3 for "meeting MVPA guideline" group; 51.8±0.4 for "meeting MSA guideline" group; 52.9±0.2 for "low sedentary" group), work time per week (35.7±0.5 for "meeting MVPA guideline" group; 35.6±1.0 for "meeting MSA guideline" group; 38.7±0.5 for "low sedentary" group)

¶P-values were derived from Rao-Scott chi-square test for categorical variables and the complex sample general linear model for continuous variables comparing between "not meeting PA guideline" vs "meeting PA guideline" or "high sedentary" vs "low sedentary" groups.

Table 3. Factors associated with not meeting PA guidelines and high sedentary time in male middle-aged workers

	Not meeting "MVPA guideline"		Not meeting "MSA guideline"		High sedentary	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Explanatory variables	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Demographic factor						
Education						
Below middle school	2.52 (2.04-3.12)	2.19 (1.80-2.67)	2.91 (2.27-3.74)	1.94 (1.31-2.87)	0.37 (0.30-0.45)	0.95 (0.69-1.32)
High school	1.40 (1.20-1.64)	1.30 (1.10-1.51)	1.31 (1.10-1.57)	1.04 (0.80-1.35)	0.46 (0.39-0.54)	0.69 (0.55-0.88)
College or higher	(ref.)	(ref.)	(ref.)	(ref.)	(ref.)	(ref.)
Residential area						
Urban	(ref.)	(ref.)	(ref.)	(ref.)	(ref.)	(ref.)
Rural	1.47 (1.23-1.76)	1.27 (1.06-1.53)	1.82 (1.46-2.28)	1.43 (1.04-1.96)	0.46 (0.38-0.55)	0.57 (0.43-0.74)
Quartiles of income						
1st(lowest)	1.54 (1.25-1.90)		1.98 (1.55-2.52)	1.77 (1.26-2.48)	0.44 (0.36-0.55)	
2nd	1.35 (1.12-1.64)		1.41 (1.15-1.74)	1.12 (0.84-1.49)	0.55 (0.46-0.67)	
3rd	1.21 (1.00-1.46)		1.36 (1.11-1.67)	1.25 (0.96-1.63)	0.72 (0.60-0.87)	
4th(highest)	(ref.)		(ref.)	(ref.)	(ref.)	
Occupational factor						
Work time per week	1.01 (1.01-1.02)	1.01 (1.01-1.02)	1.01 (1.00-1.02)	1.01 (1.00-1.02)		
Occupation category						
White-collar	(ref.)		(ref.)	(ref.)	(ref.)	(ref.)
Pink-collar	1.34 (1.07-1.69)		0.96 (0.75-1.23)	0.78 (0.52-1.18)	0.33 (0.26-0.42)	0.40 (0.28-0.59)
Blue-collar	1.60 (1.37-1.86)		2.04 (1.71-2.44)	1.27 (0.97-1.67)	0.27 (0.23-0.32)	0.34 (0.27-0.44)
Working status						
Employee	(ref.)	(ref.)			(ref.)	
Self-employed	1.39 (1.20-1.61)	1.26 (1.09-1.47)			0.82 (0.71-0.95)	
Unpaid family worker	1.79 (1.05-3.04)	1.44 (0.84-2.47)			0.54 (0.32-0.90)	
Employment type						
Full-time	(ref.)		(ref.)		(ref.)	(ref.)
Part-time	1.32 (0.97-1.81)		1.64 (1.13-2.39)		0.45 (0.33-0.62)	0.70 (0.49-1.01)
Daily worker	0.96 (0.70-1.33)		1.63 (1.10-2.42)		0.19 (0.13-0.28)	0.38 (0.24-0.59)
Employment status						
Regular			(ref.)		(ref.)	(ref.)

Temporary	1.64 (1.30-2.07)		0.41 (0.33-0.50)	0.75 (0.59-0.95)
Stress perception				
Low	(ref.)	(ref.)	(ref.)	(ref.)
High	1.34 (1.10-1.63)	1.43 (1.10-1.86)	1.13 (1.13-1.57)	1.24 (0.98-1.56)

CI, confidence interval; MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous aerobic physical activity; OR, odds ratio

Model 1 was adjusted for age.

Model 2 was adjusted for variables that were statistically significant in Model 1.

Table 4. Factors associated with not meeting PA guidelines and high sedentary time in female middle-aged workers

	Not meeting "MVPA guideline"		Not meeting "MSA guideline"		High sedentary	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Explanatory variables	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Demographic factor						
Education						
Below middle school			1.58 (1.14-2.20)		0.44 (0.35-0.55)	0.82 (0.60-1.11)
High school			1.11 (0.87-1.43)		0.61 (0.51-0.73)	1.10 (0.85-1.41)
College or higher			(ref.)		(ref.)	(ref.)
Residential area						
Urban	(ref.)	(ref.)	(ref.)	(ref.)	(ref.)	(ref.)
Rural	1.84 (1.51-2.24)	1.74 (1.41-2.14)	1.89 (1.38-2.59)	1.65 (1.20-2.27)	0.61 (0.50-0.74)	0.78 (0.60-1.03)
Quartiles of income						
1st(lowest)			1.56 (1.15-2.12)		0.58 (0.47-0.72)	
2nd			1.28 (0.97-1.69)		0.70 (0.58-0.86)	
3rd			1.24 (0.94-1.65)		0.66 (0.54-0.80)	
4th(highest)			(ref.)		(ref.)	
Occupational factor						
Work time per week	1.01 (1.01-1.02)	1.01 (1.01-1.02)	1.01 (1.00-1.02)	1.01 (1.00-1.02)	0.99 (0.99-1.00)	
Working schedule						
Day-time worker					(ref.)	(ref.)
Shift worker					0.77 (0.64-0.94)	0.80 (0.62-1.03)
Occupation category						
White-collar	(ref.)		(ref.)	(ref.)	(ref.)	(ref.)
Pink-collar	1.07 (0.89-1.29)		1.25 (0.97-1.61)	1.09 (0.85-1.39)	0.28 (0.23-0.34)	0.23 (0.18-0.30)
Blue-collar	0.93 (0.76-1.13)		2.04 (1.52-2.74)	1.71 (1.30-2.24)	0.32 (0.27-0.40)	0.37 (0.28-0.48)
Working status						
Employee	(ref.)	(ref.)			(ref.)	
Self-employed	1.50 (1.25-1.81)	1.36 (1.13-1.64)			1.05 (0.88-1.25)	
Unpaid family worker	1.74 (1.33-2.26)	1.35 (1.02-1.78)			0.61 (0.47-0.79)	
Employment type						
Full-time					(ref.)	
Part-time					0.86	

			(0.70-1.05)
Daily worker			0.84 (0.61-1.16)
Employment status			
Regular			(ref.)
Temporary			0.66 (0.54-0.80)
Stress perception			
Low	(ref.)	(ref.)	(ref.)
High	1.41 (1.10-1.82)	1.39 (1.08-1.80)	1.13 (0.96-1.34)

CI, confidence interval; MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous aerobic physical activity; OR, odds ratio

Model 1 was adjusted for age.

Model 2 was adjusted for variables that were statistically significant in Model 1.

Table 5. Adjusted time spent for physical activity and sedentary behavior by sex and occupational classification

	White-collar	Pink-collar	Blue-collar	P value*	Post Hoc
Male					
MVPA (min/week)	232.4±23.6	252.1±26.7	283.2±22.7	0.2	
OPA	36.3±16.8	62.9±16.7	117.1±18.9	<0.001	White-Blue, Pink-Blue
TPA	109.9±9.5	88.3±9.4	91.8±6.8	0.139	
LTPA	86.2±9.2	101.5±14.6	73.9±7.8	0.250	
MSA (days/week)	1.0±0.1	1.1±0.1	0.7±0.1	0.006	Pink - Blue
Sedentary time (min/day)	485.3±9.1	406.6±11.6	394.7±7.0	<0.001	White – Pink, White - Blue
Female					
MVPA (min/week)	174.1±22.8	159.0±12.7	190.7±14.8	0.1	
OPA	32.8±20.6	29.4±9.3	38.7±9.3	0.597	
TPA	100.1±9.5	85.4±7.7	114.2±9.4	0.018	Pink – Blue
LTPA	41.2±5.3	44.2±4.8	37.7±4.8	0.564	
MSA (days/week)	0.6±0.1	0.4±0.1	0.3±0.0	0.004	White - Blue
Sedentary time (min/day)	466.0±9.4	372.1±8.7	377.2±8.8	<0.001	White – Pink, White - Blue

MVPA, moderate-to-vigorous aerobic physical activity; OPA, occupational physical activity; TPA, transportation physical activity; LTPA, leisure time physical activity; MSA, muscle-strengthening activity

Data were presented as mean ± standard error.

*The p-values are derived by ANCOVA adjusted for age, education level, residential area, and income level.

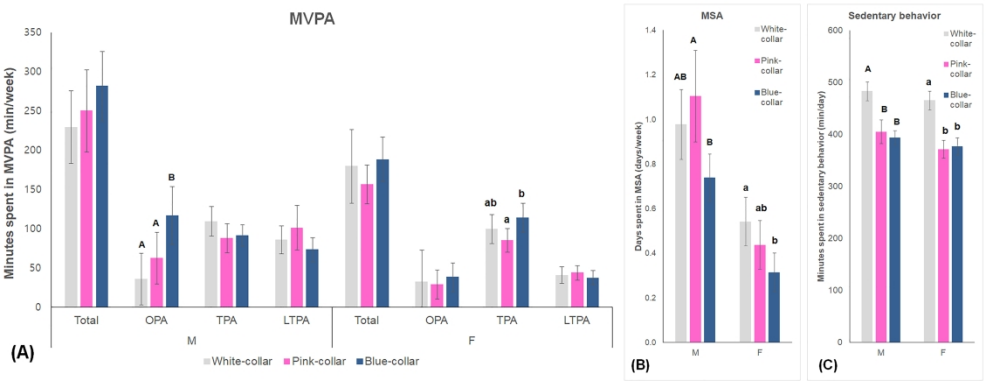

Figure 1. Comparisons of estimated time spent in MVPA (A), MSA (B) and sedentary behavior (C) adjusted by age, education level, residential area, and income level according to the type of occupation and sex in middle-aged workers in Korea. (A) For OPA, male blue-collar workers^{B} are significantly different from the white-^{A} and pink-collar workers^{A}. For TPA, female blue-collar workers^{b} are significantly different from female pink-collar workers^{a}. (B) Male pink-collar workers^{A} are significantly different from male blue-collar workers^{B}. Female white-collar workers^{a} are significantly different from female blue-collar workers^{b}. (C) White-collar workers^{Aa} are significantly different from pink-collar and blue-collar workers^{Bb} in both sexes. Error bars indicate 95% confidence intervals. MVPA, moderate-to-vigorous physical activity; OPA, occupational physical activity; TPA, transportation physical activity; LTPA, leisure-time physical activity; MSA, muscle-strengthening activities.

210x80mm (600 x 600 DPI)

Supplementary Table 1. Unweighted numbers and population-weighted estimated percentages within each sociodemographic and work-related variable category in Korean middle-aged workers.

	Current study, n (Population-weighted estimates, %)*	
	Male	**Female**
Total	3,306	3,053
Education		
Below middle school	709(15.4)	964(26.3)
High school	1,133(35.0)	1,166(40.4)
College or higher	1,464(49.7)	922(33.3)
Residence		
Urban	2,660(83.9)	2,468(84.2)
Rural	646(16.1)	585(15.8)
Family structure		
Single	264(7.2)	279(7.6)
With members	3,042(92.8)	2,774(92.4)
Income		
1st(lowest)	638(19.7)	674(22.2)
2nd	871(26.4)	827(26.7)
3rd	902(27.6)	779(26.2)
4th(highest)	891(26.2)	769(24.7)
Working schedule		
Day-time worker	2,872(86.4)	2,539(82.8)
Shift worker	428(13.4)	510(17.1)
Occupation category		
White-collar	1,268(44.2)	1,185(40.1)
Pink-collar	395(13.2)	985(32.5)
Blue-collar	1,638(42.5)	881(27.4)
Working status		
Employee	2,047(63.9)	2,094(69.8)
Self-employed	1,195(34.0)	659(21.3)
Unpaid family workers	63(2.1)	299(8.9)

Employment type		
Full-time	1,693(84.0)	1,373(65.3)
Part-time	186(8.4)	534(26.0)
Daily workers	168(7.7)	187(8.8)
Employment status		
Regular	1,266(65.2)	661(32.1)
Temporary	781(34.8)	1,433(67.9)
Stress perception-1		
Low	2,538(76.7)	2,244(73.5)
High	764(23.2)	802(26.3)
Stress perception-2		
Low	889(77.7)	813(74.2)
High-job related	108(9.2)	94(8.9)
High-other	149(13.2)	193(16.9)

*Values are presented as unweighted number (population-weighted estimated percentage).

Supplementary Table 2. Comparison of adjusted time spent on MVPA domains between "high sedentary" and "low sedentary" groups.

	Male			Female		
	High sedentary (>7hr/day)	Low sedentary (≤7hrs/day)	*p-value	High sedentary (>7hr/day)	Low sedentary (≤7hrs/day)	*p-value
OPA (min/week)	42.2±15.8	117.9±17.7	<0.001	21.8±8.2	41.9±13.5	0.018
TPA (min/week)	77.6±6.0	112.0±7.4	<0.001	80.3±5.9	114.4±6.2	<0.001
LTPA (min/week)	75.5±8.0	85.6±7.4	0.299	36.6±3.7	43.9±3.8	0.146

OPA, occupational physical activity; TPA, transportation physical activity; LTPA, leisure time physical activity

Data were presented as mean ± standard error.

*The p-values are derived by ANCOVA adjusted for age, education level, residential area, and income level.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Title/Abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page No#5
Objectives	3	State specific objectives, including any prespecified hypotheses	Page No#5~6
Methods			
Study design	4	Present key elements of study design early in the paper	Page No#6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page No#6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page No#6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page No#6~#9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page No#6~8
Bias	9	Describe any efforts to address potential sources of bias	Page No#7
Study size	10	Explain how the study size was arrived at	Page No#6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page No#7~8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page No#9~10
		(*b*) Describe any methods used to examine subgroups and interactions	Page No#9~10
		(*c*) Explain how missing data were addressed	Page No#9~10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Page No#9~10
		(*e*) Describe any sensitivity analyses	Page No#9~10
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page No#6
		(b) Give reasons for non-participation at each stage	Page No#6
		(c) Consider use of a flow diagram	Page No#6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page No#10~11

		(b) Indicate number of participants with missing data for each variable of interest	Page No#6
Outcome data	15*	Report numbers of outcome events or summary measures	Page No#10~11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page No#10~13
		(*b*) Report category boundaries when continuous variables were categorized	Page No#7~8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Irrelevant
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page No#12~13
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page No#13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page No#17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page No#13~16
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page No#13~16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page No#18

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.