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Association of occupation with the daily physical activity and sedentary behaviour 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 WHO recommends that adults engage in regular moderate-to-vigorous physical activities (MVPAs) and muscle-strengthening activities (MSA), and minimise sedentary behaviour. This study aimed to determine the association of occupation with MVPA, MSA and sedentary behaviour in middle-aged Korean workers.

Design and setting A cross-sectional study using data from the seventh Korea National Health and Nutrition Examination Survey (2016–2018).

Participants Workers aged between 40 and 69 years in Korea (n=6359).

Outcome measures Population-weighted proportions not meeting the MVPA (< 150 min/week) and MSA (< 2 days/week) guidelines, and with high sedentary behaviour (> 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 behaviour according to the occupation categories (white-collar, pink-collar and 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 behaviour was significantly associated with white-collar occupations (p<0.001 by ANCOVA). Longer working hours were negatively associated with MVPA (OR=1.01, 95% CI 1.01 to 1.02) and MSA (OR=1.01, 95% CI 1.00 to 1.02). Workers with higher stress were less likely to participate in MSA (male: OR=1.43, 95% CI 1.10 to 1.86; female: OR=1.39, 95% CI 1.08 to 1.80). Self-employed workers showed lower MVPA levels than employees (male: OR=1.26, 95% CI 1.09 to 1.47; female: OR=1.36, 95% CI 1.13 to 1.64). Daily workers compared with full-time workers (OR=0.38, 95% CI 0.24 to 0.59) and temporary workers compared with regular workers (OR=0.75, 95% CI 0.59 to 0.95) were associated with less sedentary behaviour in men.

Conclusion A number of work-related factors were associated with PA levels and sedentary behaviour in

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This is the first study in Korea to investigate moderate-to-vigorous physical activity (MVPA) and MSA participation and sedentary behaviour concurrently across occupation categories using national representative data.
⇒ This study comprehensively investigated the association of occupation with PA level and sedentary behaviour regarding various socioeconomic confounding factors.
⇒ This study assessed the MVPA level of three domains (occupational, transportation and leisure time) and sedentary behaviour together to estimate overall physical activity status accurately.
⇒ The MVPA level, MSA level and degree of sedentary behaviour were analysed 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 behaviour).
⇒ Since the study design was cross-sectional, causality cannot be inferred.

middle-aged workers. The workplace is one of the critical elements to intervene in health promotion strategies.

INTRODUCTION

Physical inactivity is a worldwide public health problem and is responsible for about 6%–10% of the global burden of major chronic noncommunicable diseases.[1] Until recently, physical activity (PA) recommendations primarily focused on moderate-to-vigorous physical activity (MVPA).[2] However, based on recent evidence, WHO's PA guidelines for public health now include muscle-strengthening activities (MSAs) 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 with meeting the guideline for only one was associated with a lower risk of all-cause mortality in cohort studies.[8]

In addition, sedentary behaviour 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 behaviour 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 behaviours, 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 occupational physical activity (OPA) and leisure-time physical activity (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 behaviour according to sociodemographic and work-related factors. The MVPA level was investigated not only in total but also by each domain (ie, occupational, transportation and leisure time).

MATERIALS AND METHODS
Data collection and participants
This study was based on data from the seventh 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 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, 6359 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).

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).

PA 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 Global Physical Activity Questionnaire (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 r 0.642–0.762).[26]

Moderate-to-vigorous physical activity
MVPA refers to PA performed at over 3 metabolic equivalents of task (METs; 3 METs three times the intensity of rest). The information on MVPA level was collected in three domains: OPA, transportation physical activity (TPA) and LTPA.[27] 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. 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 physical activity (VPA) were multiplied by two. For OPA and LTPA, moderate-intensity physical activity (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.

Muscle-strengthening activities
To assess MSA, respondents were asked, 'Over the past 7 days, how many days did you do any physical activities

Table 1 Population-weighted proportions of participants not meeting MVPA guideline, not meeting MSA guideline, and with 'high sedentary behaviour' 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 to 57.0)		73.5 (71.9 to 76.4)		51.3 (49.2 to 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 to 75.2)		84.8 (81.6 to 88.0)		37.1 (32.1 to 42.0)	
High school	57.1 (53.7 to 60.5)		74.4 (71.6 to 77.2)		42.6 (39.3 to 45.8)	
College or higher	48.6 (45.8 to 51.4)		69.4 (67.0 to 71.8)		61.9 (59.1 to 64.6)	
Residence		0.002		0.002		<0.001
Urban	53.7 (51.5 to 55.9)		72.4 (70.5 to 74.2)		54.5 (52.1 to 56.9)	
Rural	62.0 (57.2 to 66.7)		79.7 (75.8 to 83.5)		34.7 (29.8 to 39.5)	
Family structure		0.936		0.703		0.171
Single	54.7 (47.8 to 61.6)		72.4 (66.1 to 78.7)		46.4 (39.2 to 53.6)	
With members	55.0 (52.9 to 57.1)		73.6 (71.9 to 75.4)		51.7 (49.4 to 53.9)	
Quartiles of income		0.008		<0.001		<0.001
First (lowest)	59.6 (55.2 to 63.9)		80.5 (77.0 to 84.0)		40.6 (36.3 to 44.9)	
Second	57.1 (53.4 to 60.8)		74.0 (70.9 to 77.1)		46.6 (42.7 to 50.5)	
Third	54.4 (50.7 to 58.1)		75.0 (71.9 to 78.0)		54.2 (50.5 to 57.9)	
Fourth (highest)	50.2 (46.4 to 54.0)		66.5 (63.0 to 70.1)		61.2 (57.2 to 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
Daytime worker	55.4 (53.2 to 57.6)		73.8 (72.0 to 75.6)		51.7 (49.4 to 54.0)	
Shift worker	53.0 (47.4 to 58.6)		71.9 (67.1 to 76.8)		49.0 (43.7 to 54.4)	
Occupation category		<0.001		<0.001		<0.001
White-collar	48.9 (46.1 to 51.7)		69.1 (66.5 to 71.7)		66.1 (63.3 to 68.9)	
Pink-Collar	53.6 (48.2 to 59.0)		67.5 (62.6 to 72.5)		42.1 (36.9 to 47.4)	
Blue-collar	61.8 (58.8 to 64.8)		80.1 (77.7 to 82.5)		38.7 (35.6 to 41.8)	
Working status		<0.001		0.872		0.007
Employee	52.1 (49.7 to 54.6)		73.2 (71.0 to 75.4)		53.3 (50.7 to 56.0)	
Self-employed	59.8 (56.7 to 62.9)		74.2 (71.4 to 77.0)		48.5 (44.9 to 52.1)	
Unpaid family workers	65.0 (52.8 to 77.2)		74.5 (60.2 to 88.8)		34.7 (20.8 to 48.6)	
Employment type		0.002		0.031		<0.001
Full-time	51.1 (48.4 to 53.9)		72.0 (69.5 to 74.4)		58.5 (55.7 to 61.3)	

Continued

Table 1 Continued

	Not meeting MVPA guideline† % (95% CI)*	P value¶	Not meeting MSA guideline‡ % (95% CI)*	P value¶	High sedentary§(>7 hours) % (95% CI)*	P value¶
Part-time	65.7 (58.5 to 72.9)		81.4 (75.2 to 87.7)		34.3 (26.8 to 41.7)	
Daily workers	48.4 (39.6 to 57.2)		77.1 (69.6 to 84.6)		18.0 (12.1 to 23.9)	
Employment status		0.192		0.005		<0.001
Regular	51.0 (47.9 to 54.1)		70.9 (68.1 to 73.8)		61.8 (58.7 to 65.0)	
Temporary	54.3 (50.4 to 58.1)		77.4 (74.0 to 80.7)		37.5 (33.7 to 41.3)	
Stress perception-1		0.266		0.007		<0.001
Low	54.4 (52.1 to 56.7)		72.2 (70.3 to 74.2)		49.2 (46.8 to 51.6)	
High	57.0 (53.2 to 60.8)		78.0 (74.7 to 81.3)		58.2 (54.2 to 62.2)	
Stress perception-2		0.120		0.180		0.259
Low	56.2 (52.4 to 60.1)		71.7 (68.1 to 75.2)		50.2 (46.1 to 54.3)	
High—job related	67.3 (57.4 to 77.2)		77.1 (67.3 to 86.8)		58.9 (48.9 to 69.0)	
High—other	53.4 (44.5 to 62.3)		79.4 (71.9 to 87.0)		52.9 (44.4 to 61.5)	

The mean±SD of two continuous variables for participants who meet the MVPA, MSA guidelines and with low sedentary behaviour (≤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).
*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±SD.
†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 behaviour (>7 hours/day).
¶p Values were derived from Rao-Scott χ^2 test for categorical variables and the complex sample general linear model for continuous variables comparing between 'not meeting PA guideline' versus 'meeting PA guideline' or 'high sedentary' versus 'low sedentary' groups.
MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous physical activity; PA, physical activity.

Table 2 Population-weighted proportions of participants not meeting MVPA guideline, not meeting MSA guideline, and with 'high sedentary behaviour' 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 to 61.4)		86.5 (85.0 to 88.0)		44.4 (42.2 to 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 to 67.2)		89.1 (86.9 to 91.3)		33.0 (29.2 to 36.8)	
High school	57.9 (54.4 to 61.3)		86.9 (84.7 to 89.2)		42.9 (39.6 to 46.1)	
College or higher	58.0 (54.5 to 61.5)		84.0 (81.3 to 86.7)		55.3 (51.3 to 59.3)	
Residence		<0.001		0.002		<0.001
Urban	57.5 (55.2 to 59.7)		85.6 (83.9 to 87.2)		46.8 (44.3 to 49.3)	
Rural	69.7 (64.9 to 74.5)		91.6 (88.7 to 94.5)		31.6 (26.7 to 36.4)	
Family structure		0.439		0.438		0.543
Single	56.7 (49.6 to 63.9)		84.8 (80.1 to 89.4)		42.2 (35.0 to 49.5)	
With members	59.6 (57.5 to 61.7)		86.7 (85.1 to 88.2)		44.6 (42.2 to 46.9)	
Quartiles of income		0.282		0.003		<0.001
First (lowest)	62.3 (58.4 to 67.0)		90.1 (87.6 to 92.5)		37.9 (33.9 to 41.9)	
Second	60.0 (56.1 to 63.9)		87.6 (85.0 to 90.2)		44.2 (40.3 to 48.0)	
Third	57.6 (53.8 to 61.4)		86.5 (83.8 to 89.2)		42.8 (38.7 to 47.0)	
Fourth (highest)	57.7 (53.5 to 61.9)		82.5 (79.1 to 85.9)		52.6 (48.4 to 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 to 61.3)		86.7 (85.1 to 88.2)		45.9 (43.4 to 48.3)	
Shift worker	61.2 (56.1 to 66.2)		85.7 (82.1 to 89.3)		37.0 (32.2 to 41.9)	
Occupation category		0.007		<0.001		<0.001
White-collar	57.5 (54.4 to 60.6)		83.7 (81.2 to 86.1)		58.9 (55.4 to 62.3)	
Pink-collar	63.9 (60.9 to 67.0)		86.5 (84.1 to 88.9)		34.9 (31.3 to 38.5)	
Blue-collar	56.8 (52.6 to 60.9)		90.7 (88.6 to 92.9)		34.4 (30.5 to 38.4)	
Working status		<0.001		0.113		0.02
Employee	56.3 (53.8 to 58.7)		87.0 (85.3 to 88.7)		45.8 (43.2 to 48.3)	
Self-employed	66.0 (61.8 to 70.1)		84.0 (80.7 to 87.2)		43.8 (39.2 to 48.4)	
Unpaid family workers	68.3 (61.6 to 75.0)		88.8 (84.7 to 92.9)		35.2 (28.2 to 42.1)	
Employment type		0.254		0.309		0.012
Full-time	55.5 (52.4 to 58.5)		86.2 (84.1 to 88.2)		48.5 (45.2 to 51.7)	

Continued

Table 2 Continued

	Not meeting MVPA guideline† % (95% CI)*	P value¶	Not meeting MSA guideline‡ % (95% CI)*	P value¶	High sedentary§ (>7 hours) % (95% CI)*	P value¶
Part-time	56.2 (51.5 to 60.8)		88.2 (85.1 to 91.2)		40.4 (35.6 to 45.2)	
Daily worker	62.5 (54.8 to 70.2)		89.7 (84.9 to 94.6)		41.4 (33.6 to 49.2)	
Employment status		0.165		0.665		<0.001
Regular	53.9 (49.5 to 58.2)		86.5 (83.8 to 89.2)		55.5 (51.1 to 59.9)	
Temporary	57.4 (54.5 to 60.3)		87.2 (85.2 to 89.3)		41.1 (38.1 to 44.1)	
Stress perception-1		0.090		0.020		0.029
Low	58.4 (56.0 to 60.7)		85.5 (83.8 to 87.3)		43.0 (40.4 to 45.6)	
High	62.2 (58.4 to 66.0)		89.1 (86.7 to 91.5)		48.5 (44.2 to 52.8)	
Stress perception-2		0.402		0.451		0.465
Low	60.3 (56.4 to 64.3)		84.3 (81.4 to 87.3)		45.6 (41.2 to 50.0)	
High—job related	64.4 (53.4 to 75.5)		89.5 (82.5 to 96.5)		51.5 (40.7 to 62.4)	
High-other	66.3 (58.0 to 74.7)		86.4 (80.5 to 92.3)		50.3 (40.4 to 60.1)	

The mean±SD of two continuous variables for participants who meet the MVPA, MSA guidelines and with low sedentary behaviour (≤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).

*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±SD.

†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 behaviour (>7 hours/day).

¶P values were derived from Rao-Scott χ^2 test for categorical variables and the complex sample general linear model for continuous variables comparing between 'not meeting PA guideline' versus 'meeting PA guideline' or 'high sedentary' versus 'low sedentary' groups.

MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous physical activity; PA, physical activity.

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 2 or more days a week. The study's participants were dichotomised as either 'meeting the guideline' or 'not meeting the guideline', depending on their adherence to each type of PA (MVPA and MSA).

Sedentary behaviours

Sedentary behaviours are defined as behaviours with low energy expenditure (≤1.5 METs) and are distinct from the simple absence of PA.[27] The amount of sedentary behaviour was measured using the item in the K-GPAQ. Respondents reported their average time spent on sedentary behaviour per day during a typical week. Sedentary behaviour 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 behaviour exceeding 7 hours a day as 'high sedentary', based on a meta-analysis showing an increased risk of all-cause mortality around 7–8 hours a day of sedentary time.[28]

Demographic and work-related variables

We analysed the subjects' adherence to PA guidelines based on sociodemographic and work-related factors. The sociodemographic variables included age; sex; 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 10 categories (manager, professionals and related worker, office worker, service worker, sales worker, agriculture/forestry/fishery, craft and related trades workers, machine operators and assemblers, labour workers and soldier) according to the Korean Standard Classification of Occupation.[29] We further grouped types of occupation as white-collar (manager, professionals and related worker and office worker); pink-collar (service worker and sales

worker); and blue-collar (agriculture/forestry/fishery, craft and related trades workers, machine operators and assemblers and labour 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 nine types of stress sources (ie, economic problem, job stress, family, spouse, living environment, unemployment, health, family's health, etc). The second stress perception variable (stress perception 2) was made by categorisation 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 χ^2 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 behaviour. 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 to 1.938, indicating no evidence of collinearity. Analysis of covariance was used to compare the time spent on MVPA, MSA and sedentary behaviour, adjusted by sociodemographic variables that were significant in the previous analysis. The analyses were performed using SAS V.9.4, and SAS PROC SURVEY was used for complex weighting. P values of <0.05 were considered statistically significant.

Patients and public involvement

Patients and/or the public were not involved in the design, conduct, 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 behaviour

Unweighted numbers and population-weighted estimated percentages overall within each sociodemographic and work-related variable category in Korean middle-aged workers are shown in online supplemental table 1. Unadjusted analyses indicated significant differences in a number of sociodemographic and work-related factors, depending on adherence to the PA guidelines (tables 1 and 2). The education level, residential area and household income were significantly associated with MVPA in men, and MSA and sedentary behaviour in both sexes. Only residential area was associated with MVPA in women. Working hours was significantly associated with MVPA, MSA in both sexes and sedentary behaviour in women. Occupation category was significantly associated with MVPA, MSA and sedentary behaviour. Stress perception was significantly associated with MSA and sedentary behaviour in both sexes, and working schedule with sedentary behaviour in women. Working status was significantly associated with MVPA in both sexes, employment type with MVPA and MSA, and employment status with MSA in men. Sedentary behaviour 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 (tables 3 and 4). Men who had been educated up to middle school (OR=2.19, 95% CI 1.80 to 2.67) and high school graduates (OR=1.30, 95% CI 1.10 to 1.51) had a higher risk of not adhering to the MVPA guideline compared with those who had college degrees. Rural residents were less likely to meet the MVPA guideline than urban residents in both sexes (men: OR=1.27, 95% CI 1.06 to 1.53; women: OR=1.74, 95% CI 1.41 to 2.14). Workers not meeting the MVPA guideline worked longer hours than those who met the guideline (OR=1.01, 95% CI 1.01 to 1.02). Self-employed workers of both sexes (men: OR=1.26, 95% CI 1.09 to 1.47; women: OR=1.36, 95% CI 1.13 to 1.64) and female unpaid family workers (OR=1.35, 95% CI 1.02 to 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, 95% CI 1.31 to 2.87). Rural residents were less likely to meet the MSA guideline than urban residents (men: OR=1.43, 95% CI 1.04 to 1.96; women: OR=1.65, 95% CI 1.20 to 2.27). Men in the lowest income quartile were less likely to meet the MSA guideline than those in the highest quartile (OR=1.77, 95% CI 1.26 to 2.48). Workers not meeting the MSA guideline worked longer hours than those who met the guideline (OR=1.01, 95% CI 1.00 to 1.02). Female blue-collar workers were at a higher risk of not meeting the MSA guideline compared with white-collar workers (OR=1.71, 95% CI 1.30 to 2.24). Workers with higher stress were unlikely to practice the MSA guideline than those with lower stress (men: OR=1.43, 95% CI 1.10 to 1.86; women: OR=1.39, 95% CI 1.08 to 1.80).

Factors affecting high sedentary behaviour

The risk factors for high sedentary behaviour are shown in tables 3 and 4. Male high school graduates were less likely to show high sedentary behaviour than those with college degrees (OR=0.69, 95% CI 0.55 to 0.88). Male rural residents were at a lower risk of high sedentary behaviour (OR=0.57, 95% CI 0.43 to 0.74). White-collar workers were at a greater risk of high sedentary behaviour compared with pink-collar and blue-collar workers (OR=0.40, 95% CI 0.28 to 0.59 for male pink-collar workers; OR=0.34, 95% CI 0.27 to 0.44 for male blue-collar workers; OR=0.23, 95% CI 0.18 to 0.30 for female pink-collar workers; OR=0.37, 95% CI 0.28 to 0.48 for female blue-collar workers). Male daily workers compared with full-time workers (OR=0.38, 95% CI 0.24 to 0.59) and male temporary workers compared with regular workers (OR=0.75, 95% CI 0.59 to 0.95) were less likely to show high sedentary behaviour.

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

The time spent on MVPA, MSA and sedentary behaviour, 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 behaviour than pink-collar and blue-collar workers in both sexes (p<0.001).

Estimated time spent on MVPA domains according to the sedentary behaviour, 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 (men: p<0.001; women: p=0.018) and TPA (p<0.001) than 'high sedentary' group in both sexes (online supplemental table 2).

DISCUSSION

This study assessed Korean middle-aged workers' compliance with PA guidelines and the degree of the sedentary

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

Explanatory variables	Not meeting 'MVPA guideline'		Not meeting 'MSA guideline'		High sedentary	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Demographic factors						
Education						
Below middle school	2.52 (2.04 to 3.12)	2.19 (1.80 to 2.67)	2.91 (2.27 to 3.74)	1.94 (1.31 to 2.87)	0.37 (0.30 to 0.45)	0.95 (0.69 to 1.32)
High school	1.40 (1.20 to 1.64)	1.30 (1.10 to 1.51)	1.31 (1.10 to 1.57)	1.04 (0.80 to 1.35)	0.46 (0.39 to 0.54)	0.69 (0.55 to 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 to 1.76)	1.27 (1.06 to 1.53)	1.82 (1.46 to 2.28)	1.43 (1.04 to 1.96)	0.46 (0.38 to 0.55)	0.57 (0.43 to 0.74)
Quartiles of income						
First (lowest)	1.5 (1.25 to 1.90)		1.98 (1.55 to 2.52)	1.77 (1.26 to 2.48)	0.44 (0.36 to 0.55)	
Second	1.35 (1.12 to 1.64)		1.41 (1.15 to 1.74)	1.12 (0.84 to 1.49)	0.55 (0.46 to 0.67)	
Third	1.21 (1.00 to 1.46)		1.36 (1.11 to 1.67)	1.25 (0.96 to 1.63)	0.72 (0.60 to 0.87)	
Fourth (highest)	Ref.		Ref.	Ref.	Ref.	
Occupational factor						
Work time per week	1.01 (1.01 to 1.02)	1.01 (1.01 to 1.02)	1.01 (1.00 to 1.02)	1.01 (1.00 to 1.02)		
Occupation category						
White-collar	Ref.		Ref.	Ref.	Ref.	Ref.
Pink-collar	1.34 (1.07 to 1.69)		0.96 (0.75 to 1.23)	0.78 (0.52 to 1.18)	0.33 (0.26 to 0.42)	0.40 (0.28 to 0.59)
Blue-collar	1.60 (1.37 to 1.86)		2.04 (1.71 to 2.44)	1.27 (0.97 to 1.67)	0.27 (0.23 to 0.32)	0.34 (0.27 to 0.44)
Working status						
Employee	Ref.	Ref.			Ref.	
Self-employed	1.39 (1.20 to 1.61)	1.26 (1.09 to 1.47)			0.82 (0.71 to 0.95)	
Unpaid family worker	1.79 (1.05 to 3.04)	1.44 (0.84 to 2.47)			0.54 (0.32 to 0.90)	
Employment type						
Full -time	Ref.		Ref.		Ref.	Ref.
Part-time	1.32 (0.97 to 1.81)		1.64 (1.13 to 2.39)		0.45 (0.33 to 0.62)	0.70 (0.49 to 1.01)
Daily worker	0.96 (0.70 to 1.33)		1.63 (1.10 to 2.42)		0.19 (0.13 to 0.28)	0.38 (0.24 to 0.59)
Employment status						
Regular			Ref.		Ref.	Ref.
Temporary			1.64 (1.30 to 2.07)		0.41 (0.33 to 0.50)	0.75 (0.59 to 0.95)
Stress perception						
Low			Ref.	Ref.	Ref.	Ref.
High			1.34 (1.10 to 1.63)	1.43 (1.10 to 1.86)	1.13 (1.13 to1.57)	1.24 (0.98 to 1.56)

Model 1 was adjusted for age.
Model 2 was adjusted for variables that were statistically significant in model 1.
MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous physical activity; PA, physical activity; Ref., reference.

behaviour 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 behaviour was longer in men than in women. Compared with workers with high sedentary behaviour, workers with low sedentary behaviour 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

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

Explanatory variables	Not meeting 'MVPA guideline'		Not meeting 'MSA guideline'		High sedentary	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Demographic factors						
Education						
Below middle school			1.58 (1.14 to 2.20)		0.44 (0.35 to 0.55)	0.82 (0.60 to 1.11)
High school			1.11 (0.87 to 1.43)		0.61 (0.51 to 0.73)	1.10 (0.85 to 1.41)
College or higher			Ref.		Ref.	Ref.
Residential area						
Urban	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Rural	1.84 (1.51 to 2.24)	1.74 (1.41 to 2.14)	1.89 (1.38 to 2.59)	1.65 (1.20 to 2.27)	0.61 (0.50 to 0.74)	0.78 (0.60 to 1.03)
Quartiles of income						
first(lowest)			1.56 (1.15 to 2.12)		0.58 (0.47 to 0.72)	
second			1.28 (0.97 to 1.69)		0.70 (0.58 to 0.86)	
third			1.24 (0.94 to 1.65)		0.66 (0.54 to 0.80)	
fourth(highest)			Ref.		Ref.	
Occupational factor						
Work time per week	1.01 (1.01 to 1.02)	1.01 (1.01 to 1.02)	1.01 (1.00 to 1.02)	1.01 (1.00 to 1.02)	0.99 (0.99 to 1.00)	
Working schedule						
Day-time worker					Ref.	Ref.
Shift worker					0.77 (0.64 to 0.94)	0.80 (0.62 to 1.03)
Occupation category						
White-collar	Ref.		Ref.	Ref.	Ref.	Ref.
Pink-collar	1.07 (0.89 to 1.29)		1.25 (0.97 to 1.61)	1.09 (0.85 to 1.39)	0.28 (0.23 to 0.34)	0.23 (0.18 to 0.30)
Blue-collar	0.93 (0.76 to 1.13)		2.04 (1.52 to 2.74)	1.71 (1.30 to 2.24)	0.32 (0.27 to 0.40)	0.37 (0.28 to 0.48)
Working status						
Employee	Ref.	Ref.			Ref.	
Self-employed	1.50 (1.25 to 1.81)	1.36 (1.13 to 1.64)			1.05 (0.88 to 1.25)	
Unpaid family worker	1.74 (1.33 to 2.26)	1.35 (1.02 to 1.78)			0.61 (0.47–0.79)	
Employment type						
Full-time					Ref.	
Part-time					0.86 (0.70 to 1.05)	
Daily worker					0.84 (0.61 to 1.16)	
Employment status						
Regular					Ref.	
Temporary					0.66 (0.54 to 0.80)	
Stress perception						
Low			Ref.	Ref.	Ref.	
High			1.41 (1.10 to 1.82)	1.39 (1.08 to 1.80)	1.13 (0.96 to 1.34)	

Model 1 was adjusted for age.
Model 2 was adjusted for variables that were statistically significant in model 1.
MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous aerobic physical activity; PA, physical activity; Ref., reference.

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 10 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

Table 5 Adjusted time spent for physical activity and sedentary behaviour 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

Data are presented as mean±SE.

*The p values are derived by analysis of covariance adjusted for age, education level, residential area and income level.

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

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 emphasised as a public health promotion strategy irrespective of occupation. Also, since some male blue-collar workers are still
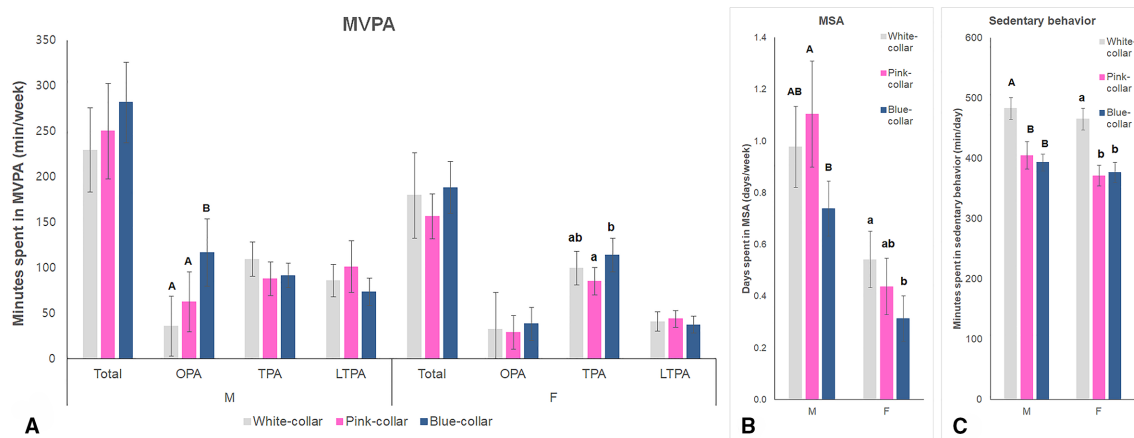
Figure 1 Comparisons of estimated time spent in MVPA (A), MSA (B) and sedentary behaviour (C) adjusted by age, education level, residential area and income level according to the type of occupation and sex in middle-aged workers in Korea. (A) For OPA, male blue-collar workers ([B]) are significantly different from white-collar ([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]). 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% CIs. LTPA, leisure-time physical activity; MSA, muscle-strengthening activities; MVPA, moderate-to-vigorous physical activity; OPA, occupational physical activity; TPA, transportation physical activity;

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 with 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 (eg, moving heavy items, digging and 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 recognised 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 favourable 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 programmes 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 Organisation 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 with daytime work, did not show any association with PA level or sedentary behaviour similar to previous findings.[19] This might be due to the heterogeneity present in different types of shift work (eg, 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 the 'higher job stress' group did not show significant difference in PA participation compared with the 'high stress from other sources' group and the '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 with 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 behaviours (eg, PA and 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 seventh highest proportion of self-employed workers in the working population among the 35 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 behaviour 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 behaviours. In men, full-time workers compared with daily workers, and regular workers compared with temporary workers engaged in sedentary behaviour 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 behaviour concurrently across occupation categories using national representative data. We assessed total MVPA level and sedentary behaviour 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 providing 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 behaviour might have recall bias. Under-reporting or over-reporting due to social desirability is possible. However, this limitation might not significantly bias our results because the KNHANES uses standardised

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 behaviour 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. Worksite intervention to provide intermittent breaks to prolonged sitting is necessary for white-collar workers. Concerning MVPA, LTPA should be primarily emphasised 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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