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Associations of sedentary time, physical activity, and cardiorespiratory fitness with metabolic syndrome in Japanese industrial workers: The Toyota Motor Corporation Physical Activity and Fitness Study

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Abstract This cross-sectional study aimed to examine the independent associations of objectively measured moderate-to-vigorous physical activity (MVPA), sedentary time (ST), and cardiorespiratory fitness (CRF) with metabolic syndrome (MetS) among industrial workers. A total of 536 Japanese male industrial workers aged 35–59 years were included in the study. MetS was defined using the 2009 Joint Interim Statement definitions. ST and MVPA were measured using a triaxial accelerometer. Maximal oxygen uptake ($\dot{V}O_2max$) was estimated through the bicycle ergometer-based submaximal aerobic fitness test. Logistic regression models were used to examine the associations of ST, MVPA, and $\dot{V}O_2max$ with MetS. The mean age was 48.6 (8.1) years, and the prevalence of MetS was 12.7%. After adjusting for covariates, the odds ratios (OR) and 95% confidence intervals (CI) of prevalent MetS for the highest and middle tertiles of MVPA were 0.22 (95% CI 0.09–0.53) and 0.89 (95% CI 0.51–1.57), respectively. The OR of the prevalent MetS for the highest and middle tertiles of $\dot{V}O_2max$ were 0.23 (95% CI 0.11–0.49) and 0.49 (95% CI 0.27–0.90), respectively. However, no significant association was found between ST and prevalence of MetS. The associations for MVPA and $\dot{V}O_2max$ did not change materially after mutual adjustment for ST, MVPA, and/or $\dot{V}O_2max$. In conclusion, higher levels of both MVPA and CRF were independently associated with a lower likelihood of MetS among Japanese male industrial workers.
Keywords : metabolic syndrome, physical activity, cardiorespiratory fitness, sedentary time

Introduction

Metabolic syndrome (MetS) is associated with an increased incidence of all-cause mortality and cardiovascular diseases (CVDs)[1)]. The prevalence of MetS using the International Diabetes Federation's metabolic syndrome criteria has been reported to range from 23.8% to 39.9% among men worldwide[2)]. MetS has also been reported in Japan, with an incidence of 11.1%–31.1% among company workers aged 30s–50s[3)]. Studies are needed to clarify the protective and/or risk factors for MetS and develop preventive strategies.

Compelling evidence indicates that a higher moderate-to-vigorous physical activity (MVPA) is associated with a lower risk of MetS[4-8)]. In addition to MVPA, prolonged sedentary time (ST) has been associated with health outcomes independent of physical activity (PA), indicating ST as a distinct risk factor[9)]. Existing evidence has shown that prolonged sedentary behaviors decreased cardiorespiratory fitness (CRF)[10,11)], and prolonged ST[9,12,13)] and low

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CRF levels[4,6,7,14] are positively associated with increased risk of MetS. Collectively, these evidences have raised the questions regarding whether the associations between CRF and MetS are independent of ST and MVPA, and vice versa. Besides, the majority of previous studies that have investigated the associations of MVPA, ST, and CRF with MetS have been limited by the self-reported data of PA measures[5,9,14], which are prone to recall bias and overestimation[15-17]. To date, few studies with available objective measures of MVPA and ST have examined the independent associations of objectively measured ST, MVPA, and CRF with MetS[7,14].

A systematic review of PA measured by a device across occupational groups showed that office workers had the greatest ST at work, whereas they had the greatest MVPA during waking hours. On the contrary, laborers had the lowest ST at work[18], suggesting that PA depends on occupation types. Studies have shown mixed evidence regarding occupational PA and health outcomes, with some studies having found higher levels of occupational PA as deleterious, whereas others have not[19]. For instance, a systematic review showed that some studies reported that manual workers were associated with increased odds of MetS; whereas others found the opposite, that is, nonmanual workers, instead of manual workers, were associated with a higher risk factor of MetS[20]. A distinction needs to be made between manual workers and nonmanual workers, especially since studies on manual workers are few and not well understood, especially among Japanese. In this study, we cross-sectionally investigated the independent associations of objectively measured total ST, MVPA, and CRF with MetS among Japanese male industrial workers.

Methods

Study design and participants. This study was a cross-sectional study of data obtained from the baseline survey of the Toyota Motor Corporation Physical Activity and Fitness Study (TMCPAFS)[21], which was conducted from October 2015 to January 2016. The study participants were 1,410 Japanese male employees of Toyota Motor Corporation aged 35–59 years, all of whom have received annual medical examinations in accordance with the Industrial Safety and Health Law of Japan. Employees were required by law to participate in annual medical examinations, and all clinical data were supplied as medical examination data[21]. We excluded 874 participants based on the following criteria: (1) valid accelerometer data could not be obtained (n = 455), (2) no data on the submaximal aerobic fitness test (n = 152), (3) not an industrial worker (n = 262), (4) a history of stroke, influence on PA could not be measured due to lower limb paralysis (n = 2), (5) unclear status as a shift worker (n = 1), and (6) unclear smoking status (n = 2). Finally, we analyzed the data from 536 male car factory workers (Fig. 1).

Ethical considerations. This study was approved by the Toyota Memorial Hospital Ethics/Personal Information Protection Management Committee (Approval no. 1507-2, approved on August 20, 2015) in accordance with the Helsinki Declaration. The purpose of the study was explained to and written informed consent was obtained from all participants.

Detailed medical examination. A questionnaire was distributed before the medical examination to obtain data on age, job type, night shift work, medical history, current smoking status, current alcohol consumption status, subjective food intake, and medications for dyslipidemia, hypertension, and hyperglycemia. The questionnaire was answered on the day of the medical examination. The participants were confirmed to have fasted for >11 h at the time of the medical examination, and all measurements

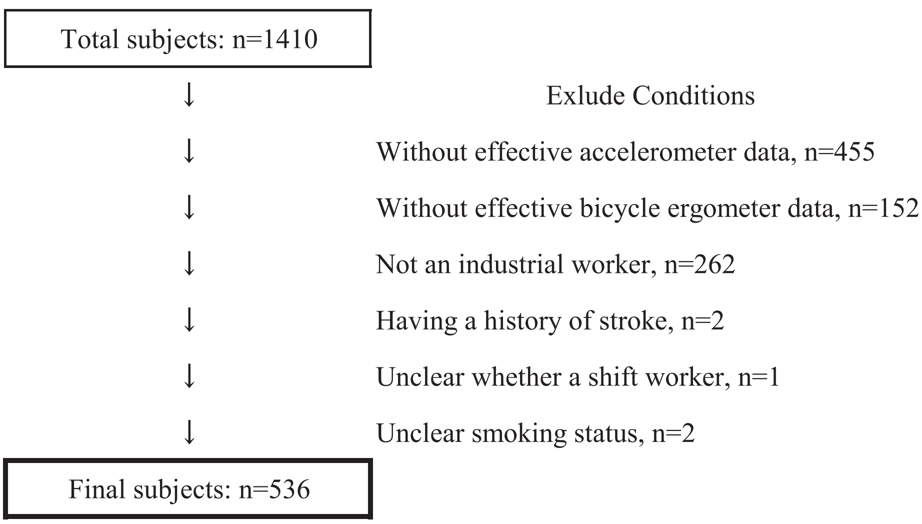

Fig. 1 Flow diagram of subjects

were performed in the morning.

Height and weight were measured using a body fat meter with an automatic height meter (BF-220; TANITA Corp., Tokyo, Japan). Waist circumference was measured at the umbilical line at the end of exhalation while breathing normally in a standing position. Blood pressure was measured using an automatic sphygmomanometer (UDEX-Twin Type 2; ELK Corp., Osaka, Japan). Blood samples were analyzed as described previously[21]. In brief, blood samples were collected from the antecubital vein to measure fasting blood glucose, triglycerides, and high-density lipoprotein cholesterol (HDL-cholesterol).

Definition of MetS. Participants were classified as either having or not having MetS according to the Joint Interim Statement (2009) definitions[22]. The MetS was defined as a case where three or more of the following five items were met: (1) waist circumference ≥ 90 cm, (2) triglyceride ≥ 150 mg/dL or taking medication for hyperlipidemia, (3) HDL-cholesterol < 40 mg/dL, (4) systolic blood pressure ≥ 130 mmHg and/or diastolic blood pressure ≥ 85 mmHg or taking medication for hypertension, and (5) fasting blood glucose ≥ 100 mg/dL or taking medication for diabetes.

PA (physical activity). Participants were instructed on how to wear an accelerometer at medical examination. Participants wore the accelerometer, which was positioned in front of the hip, during waking hours for seven consecutive days, except when bathing, doing water-based activities, and sleeping. They were required to go about their daily life as usual. They did not take a nap during the night shift. However, we could not obtain the living activity record. An accelerometer with a built-in three-axis acceleration sensor (Active style Pro HJA-750C; OMRON HEALTHCARE Co., Ltd., Kyoto, Japan) was used to objectively measure the daily PA, and the epoch time was 60 s[23]. The display screen of the device was set to display only the time to avoid promoting PA by displaying the PA data, thereby avoiding measurement bias.

Data obtained were defined as follows: ≤1.5 metabolic equivalents as ST min/day and ≥3.0 metabolic equivalents as MVPA min/day. If the activity intensity was <1.0 metabolic equivalent continuously for ≥60 min, it was recognized as not attached. A valid wear day was defined as wearing the accelerometer for ≥10 h. Participants who had ≥4 valid accelerometer wear days (regardless of working or nonworking day) were included in the analysis.

Submaximal aerobic fitness test. To evaluate estimated maximal oxygen uptake ($\dot{V}O_2max$), the submaximal aerobic fitness test was performed using the physical work capacity $(PWC)_{75\%\ HRmax}$ method (Exercise bike 75 XLIII; Konami Sports Life Co., Ltd., Kanagawa, Japan). This method has been validated using the Douglas bag method to estimate $\dot{V}O_2max$[24].

Statistical analysis. All statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Campus Drive Cary, NC, USA). The statistical significance level was set at $\alpha = 0.05$. ST and MVPA were corrected according to wearing time using the residual method, given the positive correlations of ST and MVPA with wearing time. The characteristics of the participants were shown crossing the tertiles of ST, MVPA, and $\dot{V}O_2max$, and trend tests were performed. If we have the data of continuous variables, it would be normal to use them as is, without making them categorical variables; but when interpreting the results, we decided that categorical variables would be easier. The cutoff values of the tertiles were 291.4 and 548.3 min/day for ST, 31.4 and 97.6 min/day for MVPA, and 35.4 and 44.4 mL/kg/min for $\dot{V}O_2max$. To examine the association between MetS with each of ST, MVPA, and $\dot{V}O_2max$, logistic regression analysis was performed, and the odds ratio (OR) of MetS and its 95% confidence interval (CI) were calculated. Model 1 was adjusted for age. Model 2 was adjusted for shift worker (Are you a shift worker? Yes/No), current smoking (Do you smoke habitually (for more than 6 months)? Yes/No), drinking status (Do you currently have a drinking habit? Yes/No), and subjective food intake (How much do you eat? 1. Small amount. 2. Eat until I'm 50% full. 3. Eat until I'm 80% full. 4. The amount I eat depends on the day. 5. Eat until I'm full.). Then, subjective food intake was divided into two categories (1: small amount, half, almost full; 2: not determined, fullness) in addition to model 1. In model 3, similar to model 2, MVPA was added to ST models, and ST was added to MVPA and $\dot{V}O_2max$ models as confounders. In model 4, $\dot{V}O_2max$ was added to ST and MVPA models, and MVPA to $\dot{V}O_2max$ models as confounders, similar to model 2. Finally, in model 5, MVPA and $\dot{V}O_2max$ were added to ST models, ST and $\dot{V}O_2max$ were added to MVPA models, and ST and MVPA were added to $\dot{V}O_2max$ models as confounders, similar to model 2.

Results

Characteristics of the participants. Table 1 shows the characteristics of all participants and the participants according to tertiles for ST (high, middle, and low groups), MVPA (low, middle, and high groups) and $\dot{V}O_2max$ (low, middle, and high groups). The mean ± SD age was 48.6 ± 8.1 years, and the mean waist circumference was 81.2 ± 8.9 cm. The mean triglyceride level was 115.1 ± 90.4 mg/dL; mean HDL-cholesterol level, 62.2 ± 16.3 mg/dL; mean systolic blood pressure, 117.2 ± 12.2 mmHg; mean diastolic blood pressure, 75.6 ± 7.7 mmHg; and mean fasting blood glucose level, 99.0 ± 15.7 mg/dL. A total of 68 participants (12.7%) met the MetS definition.

Table 1. Characteristics by tertile of ST, MVPA, and $\dot{V}O_2$max

Variables	ALL	ST (min/d)					MVPA (min/d)					$\dot{V}O_2$max (ml/kg/min)				
		High	Middle	Low	Chi-square test	*P* for trend	Low	Middle	High	Chi-square test	*P* for trend	Low	Middle	High	Chi-square test	*P* for trend
Nuber, n (%)	536 (100)	176 (32.9)	183 (34.1)	177 (33.0)			176 (32.9)	183 (34.1)	177 (33.0)			180 (33.6)	181 (33.8)	175 (32.6)		
Age, years	48.6 (8.1)	50.7 (7.0)	50.0 (7.6)	45.2 (8.6)		**<.0001**	49.8 (7.7)	49.7 (7.4)	46.4 (8.8)		**.001**	50.2 (8.0)	48.3 (8.1)	47.4 (8.1)		**.001**
Shift worker, n (%)					**<.0001**	**<.0001**				**<.0001**	**<.0001**				.55	.797
No	276 (51.5)	149.0 (84.7)	101.0 (55.2)	26.0 (14.7)			124 (70.5)	103 (56.3)	49 (27.7)			91 (50.6)	99 (54.7)	86 (49.1)		
Yes	260 (48.5)	27.0 (15.3)	82.0 (44.8)	151.0 (85.3)			52 (29.6)	80 (43.7)	128 (72.3)			89 (49.4)	82 (45.3)	89 (50.9)		
Body Mass Index, kg/m^2	23.2 (3.3)	23.4 (3.3)	23.2 (3.3)	23.2 (3.3)		.445	23.4 (3.5)	23.7 (3.5)	22.6 (2.8)		**.027**	24.5 (3.7)	23.1 (2.7)	22.2 (3.0)		**<.0001**
Waist circumference, cm	81.2 (8.9)	82.0 (8.3)	81.5 (8.9)	80.2 (9.3)		**.017**	82.4 (9.0)	82.2 (9.3)	79.1 (7.8)		**.0004**	85.0 (9.4)	80.5 (7.8)	78.1 (7.9)		**<.0001**
Triglyceride, mg/dL	115 (90.4)	119.3 (95.1)	110.2 (67.3)	115.9 (105.5)		.247	125.6 (119.4)	120.0 (80.9)	99.6 (59.6)		**.024**	129.6 (98.0)	117.6 (105.7)	97.5 (56.4)		**.0003**
HDL cholesterol, mg/dL	62 (16.3)	59.2 (14.8)	62.7 (16.7)	64.8 (16.9)		**.003**	59.0 (15.3)	62.0 (16.4)	65.7 (16.5)		**<.0001**	59.5 (16.6)	62.5 (15.8)	64.8 (16.0)		**.001**
Systolic blood pressure, mmHg	117 (12.2)	117.5 (12.5)	117.4 (11.9)	116.6 (12.2)		.601	117.6 (12.7)	117.1 (11.8)	116.8 (12.2)		.842	120.9 (12.5)	115.9 (11.7)	114.7 (11.5)		**<.0001**
Diastolic blood pressure, mmHg	76 (7.7)	76.3 (7.5)	75.7 (8.0)	74.8 (7.7)		.090	76.2 (7.7)	75.6 (7.3)	75.0 (8.3)		.139	77.3 (7.4)	75.0 (7.9)	74.4 (7.7)		**.0004**
Fasting blood glucose, mg/dL	99 (15.7)	101.1 (17.3)	99.4 (17.0)	97.4 (12.3)		**.035**	101.9 (17.7)	99.7 (16.8)	96.3 (11.7)		**.001**	102.5 (18.1)	99.0 (15.5)	96.3 (12.5)		**<.0001**
Medication for hyperlipidemia, n(%)	49 (9.1)	17 (9.7)	20 (10.9)	12 (6.8)		.347	14 (8.0)	24 (13.1)	11 (6.2)		.568	23 (12.8)	15 (8.3)	11 (6.3)		**.034**
Medication for hypertension, n(%)	55 (10.3)	24 (13.6)	22 (12.0)	9 (5.1)		**.008**	22 (12.5)	22 (12.0)	11 (6.2)		.052	25 (13.9)	17 (9.4)	13 (7.4)		**.045**
Medication for hyperglycemia, n(%)	28 (5.2)	13 (7.4)	7 (3.8)	8 (4.5)		.227	10 (5.7)	12 (6.6)	6 (3.4)		.332	14 (7.8)	9 (5.0)	5 (2.9)		**.037**
Metabolic syndrome†, n(%)	68 (12.7)	29 (16.5)	25 (13.7)	14 (7.9)		**.016**	31 (17.6)	30 (16.4)	7 (4.0)		**.0001**	37 (20.6)	21 (11.6)	10 (5.7)		**<.0001**
Current smorker, n (%)	212 (39.6)	63 (35.8)	67 (36.6)	82 (46.3)		**.043**	62 (35.2)	67 (36.6)	83 (46.9)		**.025**	64 (35.6)	77 (42.5)	71 (40.6)		.330
Current drinker, n (%)	421 (78.5)	140 (79.6)	149 (81.4)	132 (74.6)		.255	139 (79.0)	149 (81.4)	133 (75.1)		.379	128 (71.1)	148 (81.8)	145 (82.9)		**.007**
Subjective food intake, n (%)					.55	.432				.50	.615				.10	.089
Small amount, Half, Almost full	380 (70.9)	130 (73.9)	126 (68.9)	124 (70.1)			120 (68.2)	135 (73.8)	125 (70.6)			117 (65.0)	135 (74.6)	128 (73.1)		
Not determined, Fullness	156 (29.1)	46 (26.1)	57 (31.2)	53 (29.9)			56 (31.8)	48 (26.2)	52 (29.4)			63 (35.0)	46 (25.4)	47 (26.9)		
ST (unadjusted), min/d	392.8 (51.3)	518.7 (68.5)	413.2 (72.4)	246.6 (94.1)		**<.0001**	475.9 (112.6)	416.1 (105.8)	286.1 (116.6)		**<.0001**	398.2 (142.4)	392.3 (135.9)	388.0 (131.7)		.451
MVPA (unadjusted), min/d	101.0 (72.7)	61.5 (21.6)	85.1 (27.4)	156.8 (99.4)		**<.0001**	51.4 (12.5)	81.0 (12.3)	171.1 (89.2)		**<.0001**	88.8 (58.5)	103.6 (75.5)	111.0 (81.1)		**.001**
Wearing time, min/d	817.2 (93.1)	813.7 (85.7)	820.7 (92.2)	817.2 (101.1)		.916	830.0 (94.0)	811.4 (89.0)	810.6 (95.4)		**.036**	805.0 (84.4)	820.5 (98.5)	826.4 (95.0)		**.020**
$\dot{V}O_2$max, mL/kg/min	40.8 (10.1)	38.7 (8.7)	42.5 (10.3)	41.1 (10.7)		**.041**	39.1 (9.3)	40.4 (9.3)	43.0 (11.2)		**.0004**	30.8 (3.7)	39.9 (2.6)	52.1 (7.6)		**<.0001**

The cut point value of the tertile were 291.4 min/day and 548.3 min/day for modified ST, 31.4 min/day and 97.6 min/day for modified MVPA, and 35.4 mL/kg/min and 44.4 mL/kg/min for $\dot{V}O_2$max.
Data were represented as mean (SD) or n (%).
ST: sedentary time, MVPA: moderate-to-vigorous physical activity
†Metabolic syndrome was defined by the Joint Interim Statement (2009) definitions.

Effect of ST, MVPA, and $\dot{V}O_2$max on MetS prevalence.

Table 2 shows the results of the multiple regression analysis of MetS with ST, MVPA, and $\dot{V}O_2$max. No significant associations with ST were found in any of the models. The prevalence of MetS was reduced in all models in the highest MVPA group, 0.26 times (95% CI 0.10–0.71) in model 5, except in the middle group, which showed no significant associations. The middle and highest $\dot{V}O_2$max groups also showed a significantly lower prevalence of MetS in all models, 0.51 times (95% CI 0.28–0.95) in the middle group and 0.25 times (95% CI 0.12–0.53) in the highest group in model 5.

Discussion

This study examined the associations of ST, MVPA, and CRF with MetS based on objective data. MVPA showed a significantly lower OR in the highest group than in the lowest group. However, no significant associations between ST and MetS prevalence were found. CRF showed a significantly lower OR in the middle and highest groups compared to the lowest group. Our findings suggest that high MVPA or CRF levels, but not ST, were associated with a decreased prevalence of MetS among male industrial workers in an automobile manufacturing corporation. We confirmed and extended the findings of the protective association between MVPA or CRF with MetS in industrial workers.

A previous systematic review summarized the positive association between ST and MetS in men[12)]. The review included both self-reported and objectively measured ST. The author mentioned two limitations. First, 8 of the 10 studies used TV viewing as the surrogate marker of sitting time. PA assessed via self-reports were overestimated[15-17)] or underestimated because of recall bias[25)] compared to objective measures. Therefore, the relationship would be somewhat ambiguous. Second, eight studies had not adjusted for PA. PA, especially MVPA, has a favorable effect on MetS[4-8)]. Thus, the independent associations are unclear. In a prospective study, Honda et al.[26)] used an accelerometer and found no association between the total ST and <30 min ST with MetS prevalence. However, a positive association was observed between ST >30 min and MetS prevalence. Thus, this lack of consensus on the effects of ST on health outcomes was most likely caused by differences in measurement methods. Further studies are needed to explore the association of ST with MetS and accumulation patterns of ST.

Higher MVPA had a significantly negative association with MetS prevalence independent of ST and CRF, as assessed by accelerometer[4,27)]. However, few studies have examined whether objectively measured MVPA is associated with MetS, independent of CRF and vice versa[7,14)]. The amount and intensity of PA is associated with CRF. There are also genetic factors that determine CRF, but an increase in MVPA particularly contributes to CRF improvement[27,28)]. Therefore, by inputting each as a confounding factor, the relationship between MVPA and CRF can be clarified.

A systematic review of various occupations suggested that increasing leisure-time PA was beneficial for all workers, especially among workers with low occupational PA[29)]. What is noteworthy about the characteristics of the participants in our study is that the average total unadjusted MVPA was as high as 101.0 min/day. The Physical Activity Guidelines advocate 150 min/week of moderate-intensity PA and/or 75 min/week of vigorous-intensity PA, which our subjects appear to exceed by 1.5 days, for reducing the risk of cardiovascular diseases[30)]. Nevertheless, the results were consistent with many other studies[4,7,27)]. Even in leisure-time PA, at seven times the basic recommended level, dose–response meta-analysis found a negative linear relationship between leisure-time PA and incident MetS[8)]. Although our study used total MVPA, it showed a similar trend.

Limitations and strengths. This study has some limitations. First, the participants were employees of an automobile manufacturing corporation, and most of them were engaged in factory work. Although a few employees, such as administrators who were sedentary, were evaluated, they could not be distinguished from other employees. Second, accelerometer data mixed working days and off days because of we could not obtain a living activity record. Third, we did not adjust for the socioeconomic status such as education, income, and family structure. However, all of the industrial workers had similar years of education; moreover, their income did not differ much because they worked in the same occupational category and company. Fourth, since participants were all male car factory workers, caution should be exercised in generalizing our findings to other populations or other industrial worker categories. Finally, the cross-sectional study design precludes us from making any inferences about the causality of the observed associations.

However, this study also has some strengths. We used objective methods by evaluating the parameters of daily PA and CRF using triaxial accelerometers and the submaximal aerobic fitness test. Moreover, these independent associations were evaluated separately. Thus, our findings clarified the associations limited to industrial workers.

Conclusion

Our findings suggest that higher levels of both MVPA and CRF, but not ST, are independently associated with lower odds of MetS among Japanese industrial workers.

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Table 2. Multiple regression analysis of Metabolic syndrome† with ST, MVPA and $\dot{V}O_2max$

	Model 1			Model 2			Model 3			Model 4			Model 5		
	OR	95% CI	*p* value	OR	95% CI	*p* value	OR	95% CI	*p* value	OR	95% CI	*p* value	OR	95% CI	*p* value
ST‡															
High	1.00			1.00			1.00			1.00			1.00		
Middle	0.83	0.46-1.48	.520	0.82	0.45-1.52	.529	1.00	0.53-1.89	1.00	1.10	0.58-2.08	.774	1.27	0.66-2.45	.479
Low	0.56	0.28-1.12	.102	0.58	0.26-1.32	.193	1.06	0.44-2.58	.898	0.63	0.27-1.46	.280	0.98	0.39-2.45	.965
MVPA‡															
Low	1.00			1.00			1.00			1.00			1.00		
Middle	0.92	0.53-1.61	.771	0.89	0.51-1.57	.692	0.91	0.51-1.61	.734	0.98	0.55-1.76	.946	0.99	0.55-1.78	.964
High	0.22	0.09-0.52	**.001**	0.22	0.09-0.53	**.001**	0.23	0.09-0.61	**.003**	0.25	0.10-0.63	**.003**	0.26	0.10-0.71	**.008**
$\dot{V}O_2max$															
Low	1.00			1.00			1.00			1.00			1.00		
Middle	0.55	0.31-0.99	**.047**	0.49	0.27-0.90	**.022**	0.51	0.28-0.93	**.029**	0.51	0.28-0.95	**.032**	0.51	0.28-0.95	**.033**
High	0.26	0.13-0.55	**.0004**	0.23	0.11-0.49	**.0001**	0.24	0.11-0.51	**.0002**	0.25	0.12-0.53	**.0003**	0.25	0.12-0.53	**.0003**

†Metabolic syndrome was defined by the Joint Interim Statement (2009) definitions.
ST: sedentary time, MVPA: moderate-to-vigorous physical activity
‡Adjusted by residual method.
Model 1: Adjusted by age
Model 2: Adjusted by age, shift worke, current smork, current drink and subjective food intake
Model 3: Model 2 plus MVPA for ST, ST for MVPA and $\dot{V}O_2max$
Model 4: Model 2 plus $\dot{V}O_2max$ for ST and MVPA, MVPA for $\dot{V}O_2max$
Model 5: Model 2 plus MVPA and $\dot{V}O_2max$ for ST, ST and $\dot{V}O_2max$ for MVPA, ST and MVPA for $\dot{V}O_2max$

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Conflict of Interests

This study was conducted with research funding support from Toyota Motor Corporation. Some authors have the following affiliations: Masataka Suwa (Safety & Health Promotion Division, Health Support Center WELPO, Member), Takayuki Imoto (Safety & Health Promotion Division, Health Support Center WELPO, Group Manager), Akira Kida (Safety & Health Promotion Division, Health Support Center WELPO, Section Head), Takashi Nagami (Safety & Health Promotion Division, Health Support Center WELPO, Director), Mitsunori Iwase (Doctor, Director), Takashi Yokochi (Safety & Health Promotion Division, Health Support Center WELPO, Doctor, Director). Mitsunori Iwase is an employee of Toyota Motor Corporation (Medical Support Division, Director). Masataka Suwa and Takashi Yokochi were employees of Toyota Motor Corporation at the time of the survey. The remaining authors have no disclosures to report. However, Toyota Motor Corporation was not involved in the interpretation or conclusion of the results of this study.

Author Contributions

TI and MS conceived, designed and performed the study. TC and KY assembled and analyzed the data. SK, TC, SC and KY interpreted the data and KY wrote the paper. Writing advisory was provided by SK, TC, SC and MS. All authors approved the final version of the manuscript.

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