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Chronotype and leisure-time physical activity among civil servants in Japan: a cross-sectional analysis of the Aichi workers' cohort study

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Abstract

Background The association between chronotype and leisure-time physical activity (LTPA) remains unclear. We investigated the difference in regular LTPA and for a sufficient duration between those with evening-type (ET) and morning-type chronotypes (MT).

Methods We conducted a cross-sectional analysis using the data of the Aichi Workers' Cohort Study. It included 3,221 men (mean [standard deviation] age: 45.0 [11.6] years) and 1,294 women (39.8 [11.2] years). Chronotypes were determined with the reduced version of the Morningness-Eveningness Questionnaire. We calculated the metabolic equivalents (METs) consumed per week based on the four types of LTPA: strolling, brisk walking, light- and moderate-intensity PA, and vigorous-intensity PA. Regular LTPA and for a sufficient duration was defined as doing once or more per week and for 30 min or longer per session, respectively. Logistic regression analysis was conducted separately by sex to calculate odds ratios of ET for regular LTPA and for a sufficient duration, adjusted for age and other factors, for each type of LTPA.

Results ET men consumed fewer total METs per week than MT men ($p < .001$), although this pattern is not found in women. Compared to MT men, ET men were less likely to be engaged in regular LTPA in all types of LTPA (prevalence and adjusted odds ratio [95% confidence interval]: strolling: 39.1% vs. 28.7%, 0.685 [0.524–0.895]; brisk walking: 23.9% vs. 14.4%, 0.639 [0.454–0.899]; light- and moderate-intensity PA: 15.4% vs. 8.4%, 0.613 [0.404–0.929]; vigorous-intensity PA: 21.4% vs. 16.8%, 0.715 [0.518–0.989]). They were less likely to spend a sufficient duration in brisk walking (25.9% vs. 16.5%, 0.635 [0.461–0.875]), light- and moderate-intensity PA (37.1% vs. 26.8%, 0.684 [0.521–0.899]), and vigorous-intensity PA (35.3% vs. 35.8%, 0.741 [0.568–0.968]). Compared with MT women, ET women were less likely to be engaged in strolling (30.5% vs. 22.2%, 0.629 [0.398–0.995]), and less likely to spend a sufficient duration in light- and moderate-intensity PA (27.3% vs. 15.3%, 0.561 [0.335–0.937]).

Conclusions ET was inversely associated with LTPA in men and partly in women.

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Keywords Chronotype, Leisure-time physical activity, Civil servant, Japan, Metabolic equivalents (METs), Cross-sectional analysis

Text box 1. Contributions to the literature

- Although the association between chronotype and physical activity (PA) has been studied, few studies have exclusively focused on leisure-time PA (LTPA)
- We categorized LTPA based on intensity and examined whether Japanese civil servants with the evening-type chronotype were performing LTPA less frequency and for a shorter duration than those with the morning-type chronotype
- The associations between the evening-type chronotype and LTPA less frequently and for a shorter duration were found in both men and women, while the associations were more prominent in men than in women

Background

The optimal timing for physiological events such as sleep-wake timing and meal timing differs among individuals based on their chronotype. Individual chronotypes can be classified as morning-type (MT), neither-type (NT), or evening-type (ET), based on when they feel asleep, awake, and physically active [1]. Humans have a circadian rhythm with an approximately 24-hour cycle. Circadian clock genes synchronize all physiological functions to the earth's 24-hour cycle [2, 3], and many specific loci regulate circadian rhythms [4] and are inheritable [5]. The relationship between chronotype and health has been studied extensively. For example, ET is reportedly associated with an increased prevalence of diabetes and psychological, neurological, respiratory, and gastrointestinal/abdominal disorders, resulting in an increased risk of death [6].

Physical activity (PA), particularly leisure-time PA (LTPA), reduces the incidence of cardiovascular diseases, breast cancer, colon cancer, and diabetes [7, 8]. Many individuals do not engage in adequate PA despite awareness of its positive health effects. A survey from Japan showed that only approximately 30% of adults were performing LTPA habitually [9]. The total PA consists of that performed in leisure time, such as sports and hobbies, and that performed for a daily living, such as housework, yard work, occupational activities, and transport [10]. Previous studies have primarily focused on the association between ET chronotype and the total PA. A systematic review [11] showed that ET workers engaged in lower levels of total PA than MT workers. A study from Hungary showed that female ET workers engaged in lower levels of total PA than female MT workers [12]. ET was associated with less amount of total PA and long sedentary hours among middle-aged men in northern Finland [13]. Older ET adults engaged in less amount of total PA and had worse physical functions related to daily living, such as walking speed and balance, than older MT adults in Korea [14]. The impact of chronotypes on exercise habits was also investigated. A 12-week follow-up study in Brazil showed that ET individuals dropped out from physical exercise programs in gyms more frequently than MT individuals [15]. However, few studies have only focused on the association between chronotype and LTPA. Only Maukonen et al. [16] reported an association between ET and a few amounts of LTPA in Finland, to our knowledge.

A measure of PA used in previous studies mostly was metabolic equivalents (METs) that are calculated with the International Physical Activity Questionnaire (IPAQ). METs are the unit to indicate the intensities of PA. Although the importance of detailing LTPA type, frequency, and duration was advocated [17], this idea was little applied to previous studies that examined the association between chronotype and PA.

This study aimed to investigate the differences in LTPA between Japanese workers with ET and MT chronotypes by categorizing LTPA according to the frequency and duration of different types of LTPA at different intensities.

Methods

Study design

We conducted a cross-sectional analysis.

Participants

We used the data from the Aichi Workers' Cohort Study collected in 2018. This prospective cohort study was launched in 1997 enrolling civil servants in Aichi Prefecture [18–21]. Questionnaire surveys on their lifestyles were administered approximately every 5 years for this cohort study. In the 2018 survey, the eligible participants were 11,954 full-time civil servants. A total of 5,543 (46.4%) provided consent and responded to the survey. We excluded participants who did not completely respond to the reduced version of the Morningness-Eveningness Questionnaire (rMEQ) [22] ($n=58$) and who did not report a physical disability in daily living ($n=170$). We also excluded those who were working late at night or in shifts ($n=800$) because of the different distribution of chronotypes [23]. We finally analyzed the remaining 4,515 workers (37.8%).

Study variables

Chronotype

The rMEQ was used to determine the chronotype of the subjects [22]. The questionnaire comprised the following five items: (1) "At what time of the day do you think that you reach your 'feeling best' peak?" The possible responses and the score assigned to the response were: 5:00–8:00 (score: 5); 8:00–10:00 (score: 4); 10:00–17:00 (score: 3); 17:00–22:00 (score: 2); 22:00–5:00 (score: 1); (2) "At what time in the evening do you feel tired and, as a result, in need of sleep?" 20:00–21:00 (score: 5); 21:00–22:15 (score: 4); 22:15–0:45 (score: 3); 0:45–2:00 (score: 2); later than 2:00 (score: 1); (3) "Considering only your own 'feeling best' rhythm, at what time would you get up if you were entirely free to plan your day?" 5:00–6:30 (score: 5); 6:30–7:45 (score: 4); 7:45–9:45 (score: 3); 9:45–11:00 (score: 2); later than 11:00 (score: 1); (4) "During the first half hour after having woken in the morning, how tired do you feel?" Very tired (score: 1); Fairly tired (score: 2); Fairly refreshed (score: 3); Very refreshed (score: 4); and (5) "One hears about 'morning' and 'evening' type of people. Which ONE of these types do you consider yourself to be?" Definitely a 'morning' type (score: 6); Rather more a 'morning' type than an 'evening' type (score: 4); Rather more an 'evening' type than a 'morning' type (score: 2); Definitely an 'evening' type (score: 0). Those with the total scores of 4–11 were categorized as ET, 12–17 as NT, and 18–25 as MT.

LTPA and METs

We measured LTPA and METs by partly using the Japan Public Health Center-based prospective study-physical activity questionnaire (JPHC-PAQ) [24, 25]. Its validity on LTPA was guaranteed by previous studies [24, 25]. The intensity of physical activities and METs based on the responses to the JPHC-PAQ were well correlated with those based on the 24-hour physical activity record [24, 25].

The participants were asked to indicate the frequency of LTPA during the preceding year from the following five possible responses: less than once a month, once to three times a month, once or twice a week, three or four times a week, and almost every day. They were also asked to indicate the duration of that LTPA per session from the following six responses: < 30 min, 30–59 min, 1–2 h, 2–3 h, 3–4 h, and >4 h. The participants were asked to indicate frequency and duration for the following four types of LTPA: strolling, brisk walking, light- and moderate-intensity PA, such as golf, gateball, and gardening, and vigorous-intensity PA, such as tennis, jogging, aerobics, and swimming. We defined regular LTPA and for a sufficient duration as doing once or more per week and 30 min or longer per session, respectively, referring to the definition of the National Health and Nutrition Survey, Japan [9] and the recommendation of the Japan Sports Agency [26].

For the calculation of METs, intensities of strolling, brisk walking, light- and moderate-intensity PA, and vigorous-intensity PA were set at 2.8, 4, 3, and 6 METs/hour, respectively. These METs were defined by referring to the existing study [24]. To estimate the total weekly METs consumed by LTPA for each participant, LTPA frequency of less than once a month, one to three times a month, once or twice a week, three to four times a week, and almost every day were converted to 0, 0.5, 1.5, 3.5, and 7 times/week, respectively. LTPA duration of <30 min, 30–59 min, 1–2 h, 2–3 h, 3–4 h, and >4 h were converted to 0.25, 0.75, 1.5, 2.5, 3.5, and 4 h, respectively [27]. Referring to a previous Japanese study [28], we classified the subjects into four groups based on the total weekly METs: 0; more than 0 and 7.5 or less; more than 7.5 and 15 or less; and more than 15.

Potential confounders

Referring to the existing evidence [29–34], we assessed body mass index (BMI), medicine use, low back pain, knee pain, current drinking, and current smoking as the potential confounders or the association between chronotype and LTPA. Furthermore, we also introduced the number of days for which the subjects worked overtime for longer than 5 h. BMI was calculated based on the self-reported height (cm) and weight (kg). Medication use was inquired for hypertension, dyslipidemia, diabetes, gout, osteoporosis, stroke, depression, or any other diseases. The presence of low back pain and knee pain as well as smoking and drinking habits and the number of days of overtime working for longer than 5 h were self-reported.

Statistical analyses

Owing to potential differences by sex in the frequency and duration of LTPA, all analyses were conducted separately by sex [9, 35–38]. Differences in the categories of the total weekly METs consumed for LTPA differed according to chronotype were examined using the chi-square test. Binomial logistic regression analysis was adopted to investigate the association between chronotype and LTPA frequency and duration adjusted for age, BMI, medication use, low back pain, knee pain, current smoking, current drinking, and the number of days overtime work over 5 h. A variance inflation factors (VIF) of 10 or greater suggested multicollinearity. A two-way analysis of variance was used to examine the interaction of sex and chronotype for regular LTPA and for a sufficient duration. $P<.05$ was considered statistically significant. All analyses were calculated using the IBM SPSS Statistics version 28.

Table 1 Characteristics of subjects

	Male (n = 3221)		Female (n = 1294)	
Age (mean, SD)***, a)	45.0	(11.6)	39.8	(11.2)
Body mass index (mean SD)***, a)	23.1	(3.1)	21.3	(3.1)
Chronotype				
Morning type	1211	(37.6)	498	(37.9)
Neither type	1641	(51.0)	652	(50.8)
Evening type	369	(11.5)	144	(11.4)
Total METs consumed per week by LTPA (median, range)***, b)	6.3	(0–165.9)	2.6	(0–121.7)
Performing LTPA				
Regularly				
Strolling***	1115	(34.6)	360	(27.8)
Brisk walking***	644	(20.0)	181	(14.0)
Light- and moderate-intensity***	405	(12.6)	104	(8.0)
Vigorous intensity***	603	(18.7)	125	(9.7)
For sufficient duration				
Strolling	1140	(35.4)	461	(35.6)
Brisk walking	734	(22.8)	265	(20.5)
Light- and moderate-intensity***	1074	(33.3)	312	(24.1)
Vigorous intensity***	1142	(35.5)	288	(22.3)
Low back pain*	981	(30.4)	357	(27.6)
Knee pain	377	(11.7)	134	(10.4)
Taking medications***	818	(25.4)	261	(20.2)
Taking antidepressant	59	(1.8)	19	(1.5)
Days of overtime working (mean SD)	0.53	(2.08)	0.45	(1.85)
Current smoking***	407	(12.6)	16	(1.2)
Current drinking***	2670	(82.9)	855	(66.1)

METs: Metabolic equivalents; LTPA: Leisure-time physical activity

Figures are presented as the numbers (%)

* $p < .05$; ** $p < .01$; *** $p < .001$ for the difference by sex

P values were calculated with chi-square test, except for (a) t-test and (b) Mann–Whitney U test

Results

The prevalence of MT and ET were 37.6% and 11.5% in men and 37.9% and 11.4% in women, respectively (Table 1). The prevalence did not differ between men and women. The total METs per week consumed by LTPA was higher in men than in women. Men were more likely to engage in regular LTPA of all intensities, i.e., strolling, brisk walking, light- and moderate-intensity activities, and vigorous-intensity activities, compared to women. Men were more likely to perform LTPA for sufficient duration in light and moderate intensity and vigorous intensity, compared to women. BMI, the prevalence of low back pain, medication use, current smoking, and current drinking differed significantly between men and women. MT individuals were older than NT and ET individuals. The mean (standard deviation) ages of MT, NT, and ET individuals were 48.6 (10.2), 43.6 (11.7), and 39.3 (11.5) years old in men, 41.3 (10.8), 39.1 (11.2), and 37.4 (11.4) years old in women, respectively.

Chronotype was significantly associated with the METs consumed by LTPA per week in men. A similar tendency was observed in women, although it is not statistically significant (Table 2).

Table 3 shows the associations between chronotypes and regular LTPA and for a sufficient duration in men. ET men are less likely to engage in regular LTPA all types of LTPA, compared to MT men. ET men were not strolling for a sufficient duration more frequently than MT men. MT men consumed a sufficient duration for brisk walking, light- and moderate-intensity PA, and vigorous-intensity PA more frequently than ET men. We found no VIF of 10 or greater.

Table 4 shows the associations between chronotype and regular LTPA and sufficient duration in women. ET women were less likely to engage in only strolling regularly than MT women. This pattern was not found for brisk walking, light- and moderate-intensity, and vigorous-intensity PA. Regarding LTPA for a sufficient duration, MT was associated only with light- and moderate-intensity PA in women. Overall, women were less significantly associated with chronotype and regular LTPA

Table 2 Metabolic equivalents (METs) consumed per week by leisure-time physical activity: compared by type of chronotype

Weekly METs	n (%)		Chronotype						
			Morning Type		Neither Type		Evening Type		p
Male									
0	563	(17.5)	168	(13.9)	312	(19.0)	83	(22.5)	< .001
more than 0 to 7.5	1212	(37.6)	418	(34.5)	647	(39.4)	147	(39.8)	
more than 7.5 to 15	596	(18.5)	233	(19.2)	295	(18.0)	68	(18.4)	
15 or more	850	(26.4)	392	(32.4)	387	(23.6)	71	(19.2)	
Female									
0	343	(26.5)	127	(25.5)	177	(27.1)	39	(27.1)	.327
more than 0 to 7.5	579	(44.7)	213	(42.8)	296	(45.4)	70	(48.6)	
more than 7.5 to 15	202	(15.6)	84	(16.9)	94	(14.4)	24	(16.7)	
15 or more	170	(13.1)	74	(14.9)	85	(13.0)	11	(7.6)	

Figures are presented as the numbers (%)

P values were calculated with chi-square test

Table 3 Proportions of LTPA and odds ratios of chronotype on LTPA in men ($n = 3221$)

	n(%)		Model 1 OR (95% CI)		Model 2 OR (95% CI)	
Regular LTPA						
Strolling						
Morning type	473	(39.1)	1	(reference)	1	
Neither type	536	(32.7)	.762***	(.651 – .893)	.772**	(.657 – .907)
Evening type	106	(28.7)	.637***	(.491 – .827)	.685**	(.524 – .895)
Brisk Walking						
Morning type	289	(23.9)	1		1	
Neither type	302	(18.4)	.776**	(.644 – .934)	.790*	(.654 – .955)
Evening type	53	(14.4)	.619**	(.446 – .859)	.639*	(.454 – .899)
Light- and moderate-intensity PA						
Morning type	187	(15.4)	1		1	
Neither type	187	(11.4)	.754*	(.604 – .942)	.767*	(.611 – .961)
Evening type	31	(8.4)	.573**	(.381 – .863)	.613*	(.404 – .929)
Vigorous-intensity PA						
Morning type	259	(21.4)	1		1	
Neither type	282	(17.2)	.708***	(.584 – .859)	.725**	(.595 – .884)
Evening type	62	(16.8)	.647**	(.472 – .887)	.715*	(.518 – .989)
Performing LTPA for sufficient duration						
Strolling						
Morning type	454	(37.5)	1		1	
Neither type	557	(33.9)	.810**	(.691 – .949)	.810*	(.689 – .952)
Evening type	129	(35.0)	.806	(.627–1.037)	.832	(.642–1.078)
Brisk Walking						
Morning type	314	(25.9)	1		1	
Neither type	359	(21.9)	.829*	(.694 – .990)	.833*	(.695 – .999)
Evening type	61	(16.5)	.605**	(.444 – .826)	.635**	(.461 – .875)
Light- and moderate-intensity PA						
Morning type	449	(37.1)	1		1	
Neither type	526	(32.1)	.823*	(.702 – .966)	.821*	(.698 – .966)
Evening type	99	(26.8)	.656**	(.503 – .856)	.684**	(.521 – .899)
Vigorous-intensity PA						
Morning type	427	(35.3)	1		1	
Neither type	583	(35.5)	.803**	(.682 – .946)	.820*	(.693 – .969)
Evening type	132	(35.8)	.667**	(.515 – .864)	.741*	(.568 – .968)

LTPA: Leisure-time physical activity; PA: Physical activity

* $p<.05$, ** $p<.01$, *** $p<.001$

In Model 1, age was adjusted. In Model 2, in addition to age, body mass index, medication use, low back pain, knee pain, days of overtime working, current smoking, and current drinking were adjusted

and sufficient duration than men. We found no VIF of 10 or greater.

We found a significant interaction of sex and chronotype for brisk walking for a sufficient duration ($F=3.136$, $p=.044$). We did not find a significant interaction for doing the other types of LTPA for a sufficient duration or for regular LTPA.

Discussion

We examined the difference in the frequency and duration of LTPA between MT and ET civil servants in Japan. We found that ET men consumed fewer METs by LTPA per week than MT men. Compared with MT men, ET men are less likely to engage in regular LTPA for all kinds of LTPA. ET men were less likely to perform brisk walking, light- and moderate-intensity PA, and vigorous-intensity PA for a sufficient duration than MT men. Compared with MT women, ET women are less likely to engage in regular LTPA in strolling. ET women were performing light- and moderate-intensity PA for a sufficient duration more often than MT women.

This study excluded shift workers. It is noted that a high proportion of shift workers are ET, compared to fixed workers [23]. We aimed to examine the association between chronotype and LTPA, not shift working and LTPA. Our findings may be supported by previous behavioral findings. Miyazaki et al. [39] measured PA amounts of college students in Japan throughout the

Table 4 Proportions of LTPA and odds ratios of chronotype on LTPA in women ($n = 1294$)

	n(%)		Model 1 OR (95% CI)		Model 2 OR (95% CI)	
Regular LTPA						
Strolling						
Morning type	152	(30.5)	1		1	
Neither type	176	(27.0)	.813	(.627–1.054)	.824	(.633–1.074)
Evening type	32	(22.2)	.611*	(.393 – .949)	.629*	(.398 – .995)
Brisk Walking						
Morning type	83	(16.7)	1		1	
Neither type	85	(13.0)	.774	(.556–1.076)	.785	(.561–1.099)
Evening type	13	(9.0)	.525*	(.283 – .976)	.563	(.299–1.063)
Light- and moderate-intensity PA						
Morning type	55	(11.0)	1		1	
Neither type	42	(6.4)	.588*	(.385 – .897)	.625*	(.407 – .960)
Evening type	7	(4.9)	.459	(.203–1.036)	.532	(.231–1.224)
Vigorous-intensity PA						
Morning type	48	(9.6)	1		1	
Neither type	63	(9.7)	1.031	(.693–1.533)	.950	(.632–1.427)
Evening type	14	(9.7)	1.061	(.565–1.993)	.794	(.391–1.612)
Performing LTPA for sufficient duration						
Strolling						
Morning type	180	(36.1)	1		1	
Neither type	224	(34.4)	.872	(.681–1.117)	.890	(.629–1.145)
Evening type	57	(39.6)	1.047	(.712–1.541)	1.076	(.720–1.609)
Brisk Walking						
Morning type	101	(20.3)	1		1	
Neither type	132	(20.2)	1.012	(.756–1.354)	1.027	(.763–1.383)
Evening type	32	(22.2)	1.152	(.733 – 1.810)	1.148	(.719–1.833)
Light- and moderate-intensity PA						
Morning type	136	(27.3)	1		1	
Neither type	154	(23.6)	.875	(.667–1.147)	.886	(.672–1.169)
Evening type	22	(15.3)	.532*	(.323 – .878)	.561*	(.335 – .937)
Vigorous-intensity PA						
Morning type	104	(20.9)	1		1	
Neither type	148	(22.7)	1.069	(.804–1.422)	1.004	(.750–1.345)
Evening type	36	(25.0)	1.176	(.759–1.824)	.990	(.623–1.574)

LTPA: Leisure-time physical activity; PA: Physical activity

* $p < .05$

In Model 1, age was adjusted. In Model 2, in addition to age, body mass index, medication use, low back pain, knee pain, days of overtime working, current smoking, and current drinking were adjusted

week. They found that ET students exhibited smaller PA amounts than MT students on Saturdays, while the PA levels of both types of students were of no difference on weekdays. Roenneberg et al. [40] showed that ET individuals woke up later than MT individuals on holidays, while both MT and ET individuals presented similar sleep patterns, i.e., similar sleep onset and wake-up times, on workdays. These findings suggest a potential phenomenon underlying our findings that late wake-up of ET people on weekends reduces the amount of time available for LTPA, resulting in a small amount of LTPA. A limitation of our study is that we had no data to determine whether the duration of leisure time and LTPA differed between weekdays and holidays and by chronotype. Further research is needed to address this question.

Our novelty lies in detailing LTPA type, frequency, and duration, which helped us unveil the pattern of LTPA associated with chronotype and its similarity between and difference by sex. Chronotype was not associated with the total weekly METs consumed by LTPA in women. However, ET women were less likely to engage in strolling and brisk walking regularly and they also showed a lower duration for light- and moderate-intensity PA when compared to MT women. Another interesting finding is that there was no difference in the prevalence of LTPA for a sufficient duration among MT, NT, and ET women, except for light- and moderate-intensity PA. It could suggest that once ET women begin strolling, brisk walking, and vigorous-intensity PA, they continue the LTPA as long as MT women do. This finding was similar to that for men regarding strolling, but not regarding brisk walking and vigorous-intensity PA. We found a significant sex-and-chronotype interaction for brisk walking, while we failed it for vigorous-intensity PA. This series of findings suggests the difference between men and women in how long they keep performing LTPA once they begin it, warranting future studies to detail it.

Although the primary aim of this study was to compare MT and ET individuals in terms of the frequency and duration of LTPA, we also found interesting results regarding the variances between MT and NT individuals. NT men engaged in regular and sufficiently long LTPA more often than MT men. NT women performed light- and moderate-intensity PA less frequently than MT women. Similar findings were observed in other populations as well. Sus et al. found that older adults with NT chronotype had lower levels of PA compared to those with MT chronotype [41]. Yang et al. reported a correlation between the chronotype scores and the frequency of engaging in light- and moderate-intensity PA among school-age children [42]. It would be valuable to further investigate whether NT individuals exercise less frequently and for a shorter duration across various populations.

We thought that age would confound the association between chronotype and LTPA at the time of planning the present study. Previous studies reported that both the chronotype [37] and the frequency and duration of LTPA [43, 44] varied by age. In our study, the association between ET and performing vigorous-intensity PA for sufficient duration in men became prominent when age was adjusted in the logistic regression analysis. The fact in our study is that the older subjects aged 40 years old or older reported ET and were performing vigorous-intensity PA for sufficient duration less frequently than the younger subjects aged less than 40 years old (Supplementary Tables 1–3), supporting our idea that age must be adjusted when examining the association between chronotype and LTPA.

We here discuss the prevalence of ET and its effect on the present findings. There are few existing reports on the prevalence of ET in Japan. A previous study in Japan reported that the prevalence of ET evaluated with the MEQ was only 2.3% in male chemical factory employees [45]. Our study showed a much higher prevalence of ET in men, 11.5%. The prevalence of ET could differ by occupation. In addition, the prevalence of ET did not differ by sex in our study, meaning that women also presented a high prevalence of ET, 11.4%. A similar finding was reported in Japan [38]. We found few references on the associations between occupational types and chronotype or LTPA. On the other hand, ET was more prevalent in working-age men than working-aged women in Germany and Switzerland [29, 37]. The high prevalence of ET in both men and women might lead to discovering the association between ET and performing LTPA less frequently and not for 30 min or longer in both men and women in our study.

We here discuss the validity of measuring LTPA in our study. We used the JPHC-PAQ that was validated to measure LTPA and METs [24, 25]. We observed that women were performing LTPA less than men. This finding is compatible with the existing data. According to the data of the Ministry of Health, Labor, and Welfare, Japan [9], 20.2% of men and 14.9% of women aged 30 to 50 are performing LTPA twice or more a week and 30 min or longer a session. This kind of difference is observed also in other countries. A study conducted in a rural Midwestern U.S. community showed that women spend 41% less time per week performing moderate- and vigorous-intensity PA than men [46]. In addition, a study that recruited subjects from 12 countries showed that women have fewer odds of performing LTPA than men [47]. Therefore, we believe that our way of measuring how often and how long they were performing LTPA was valid.

Study limitation

First, owing to the cross-sectional study design, we could not determine a causal relationship between chronotype and LTPA. Longitudinal studies are necessary to determine causal relationships. In this study, we asked the subjects to recall the frequency and duration of LTPA for the previous 12 months. We did not indicate the recall period for the chronotype. Therefore, the results of the present study could suggest the impact of LTPA on chronotype. However, the extent to which people accurately recall things from the past varies by person. Longitudinal studies are essential to avoid the recall bias and determine the causal relationship. Second, we discuss the possibility that the confounders we chose could as the intermediates. We chose the confounders by reference to the existing literature [29–34]. However, diseases, such as hypertension, diabetes, and stroke, may influence chronotype and LTPA, while they could be on the causal path between them, for example. Namely, some factors that we employed as the confounders could intermediate the association between chronotype and LTPA. Finally, this study focused only on civil servants working in a prefecture in Japan. The prevalence of ET and LTPA could differ by occupation. It is unclear whether our findings can be generalized to individuals of other occupations.

Conclusions

We examined the associations between chronotype and LTPA. Men and women shared the associations between ET and a low level of LTPA, although there are some differences in the findings between men and women. Further research is needed to detail the causal relationship between chronotype and LTPA and the difference by sex in various occupational settings.

Abbreviations

ANOVA	Analysis of variance
BMI	Body mass index
ET	Evening type
IPAQ	International Physical Activity Questionnaire
METs	Metabolic equivalents
MT	Morning type
NT	Neither type
PA	Physical activity
rMEQ	Reduced version of the Morningness-Eveningness Questionnaire

Supplementary Information

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Supplementary Material 1

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Author contributions

R.O., H.Y., and A.O. conceived the study. H.Y. collected data. R.O. and A.O. analyzed the data. R.O., H.Y., and A.O. interpreted the results and drafted the manuscript. All the authors critically revised the draft and approved the final manuscript. H.Y. and A.O. obtained grants for this study.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study adhered to the principles of the Declaration of Helsinki. Informed consent was obtained from all participants. Ethical approval was obtained from the Institutional Review Board of Fujita Health University (No. HM 20–416).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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