ORIGINAL ARTICLE

Relationships between current and past exercise habits and chronotype and body composition among female university students

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ABSTRACT

The present cross-sectional study investigated relationships between past and current exercise habits, body composition, and chronotypes in female university students. Physical activity, Morningness-Eveningness Questionnaire (MEQ) scores and body composition were assessed in 251 students. Participants were asked about their current exercise habits and in high school habits; each measure was compared among students with consistent exercise habits since high school (EX-EX, n = 84), those with exercise habits only in high school (EX-NO, n = 81), and those without consistent exercise habits since high school (NO-NO, n = 86). The MEQ scores of NO-NO were significantly lower than those of EX-EX and EX-NO, and approximately 40% of NO-NO were of the evening type. However, the MEQ scores were not significantly different between EX-EX and EX-NO. Furthermore, about 51% of NO-NO had body fat ≥30% even with a normal range of body mass index, which was proportionately higher than in the other groups. These results suggest that students who had an exercise habits in high school did not show differences in chronotypes owing to their current exercise habits. However, students without consistent exercise habits since high school may be associated with the late chronotype and higher prevalence of normal weight obesity.

Keywords: Sport medicine, Physical activity, Morningness-Eveningness Questionnaire, Normal weight obesity, Adolescent, Body fat, Muscle mass.

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INTRODUCTION

The university period in a student's life is considered to be an appropriate stage for the acquisition of healthy lifestyle habits, given the transition to an autonomous life (Sempere-Rubio et al. 2022). Nevertheless, universities are also known to facilitate the transition to an unhealthy lifestyle compared to previous school years. A recent review found that although physical activity (PA) declines with transition from high school to university, changes in dietary habits are inconsistent (Winpenny et al. 2020). Furthermore, such a decrease in PA is also reported to be associated with an increase in body weight or body mass index (BMI) (Crombie et al. 2009; Winpenny et al. 2020). Lower PA and/or sedentary behaviour may also be associated with an imbalance in body composition, such as 'normal weight obesity' (NWO) (Wijayatunga and Dhurandhar 2021). In particular, PA among young people in many countries has been reported to be lower in females than in males (Bauman 2009). Indeed, a recent study on female university students found that even those students who had previously exercised regularly had reduced muscle mass if their current PA level (PAL) was low, despite no difference being observed in BMI (Oshita and Myotsuzono 2021) and it is associated with the NWO (Oshita, Myotsuzono and Tashiro, 2022). Therefore, young females, such as university students, are more likely to be physically inactive, making it important to focus on their body composition.

Regarding daily rhythms, individuals exhibit a time orientation, known as the chronotype. The sharp maximum of lateness in the chronotype [i.e., transition to an evening type (ET)] occurs around the age of 20 years (Roenneberg et al. 2004). Although associations between this later chronotype (i.e., ET) and various lifestyle behaviours have been described, an association with PA has also been observed. Recent systematic reviews have found that a later chronotype is associated with less physical activity and more sedentary behaviour (Sempere-Rubio et al. 2022). In addition, a recent study of female university students reported that later chronotype and lower PA were significantly associated with higher body fat and lower muscle mass and suggested the need for chronotype-specific interventions to achieve appropriate body composition (Oshita et al. 2024). Therefore, research on the body composition of university students should focus not only on lifestyle behaviours, but also on their chronotypes.

However, the aforementioned systematic review found that although a chronotype is definitely associated with PA after the mid-20s, the association is weaker in university students and individuals in other age groups (Sempere-Rubio et al. 2022). In contrast, another review reported that an early chronotype [morning type (MT)] exhibited higher PAL and less sedentary behaviour than ET in children and adolescents (Huang et al. 2024). Therefore, association of the chronotype of university students need to be considered not only with current PA but also with past PA. This means that even if students did not have a habit of PA at the university level, if they did have this habit during adolescence, such as in high school, their chronotype may differ from that of those who did not have a consistent PA habit. Furthermore, it may be important to investigate the relationship between such differences and body composition as a health-related factor. Therefore, the present study investigated the relationship between high school and current exercise habits and body composition or chronotypes among female university students.

MATERIAL AND METHODS

Participants

The participants were 304 Japanese female university students aged between 18 and 22 years. Of these, 29 participants who provided incomplete responses in the survey were excluded. In addition, 15 participants with a PA level (PAL) >2.3 were excluded because extremely high PAL may influence the chronotype, as reported in a previous study (Oshita et al. 2024). The remaining 260 participants were divided into two groups:

those with current exercise habits (n = 93) and those without exercise habits (n = 167). Among the participants who did not have current exercise habits, those who also did also not have exercise habits in high school were classified as the NO-NO group (n = 86), and those who had exercise habits in high school were classified as the EX-NO group (n = 81). Among the participants who had current exercise habits, those who had also had exercise habits in high school were classified as the EX-EX group (n = 84). As only nine participants had no exercise habits in high school as well as current exercise habits (NO-EX), they were excluded from the study. For ethical reasons, participants were informed in advance that the survey would be anonymous, that it would be used for the purpose of this study and not for any other purpose, and that any data not used in the study would be discarded. If the results of the survey were to be published, the participants were informed that the data collected would be statistically processed and then published in such a way that individuals could not be identified and that the survey would only be carried out if participants consented. This study was approved by the Research Ethics Committee of Kyushu Kyoritsu University (approval number: 2022–08).

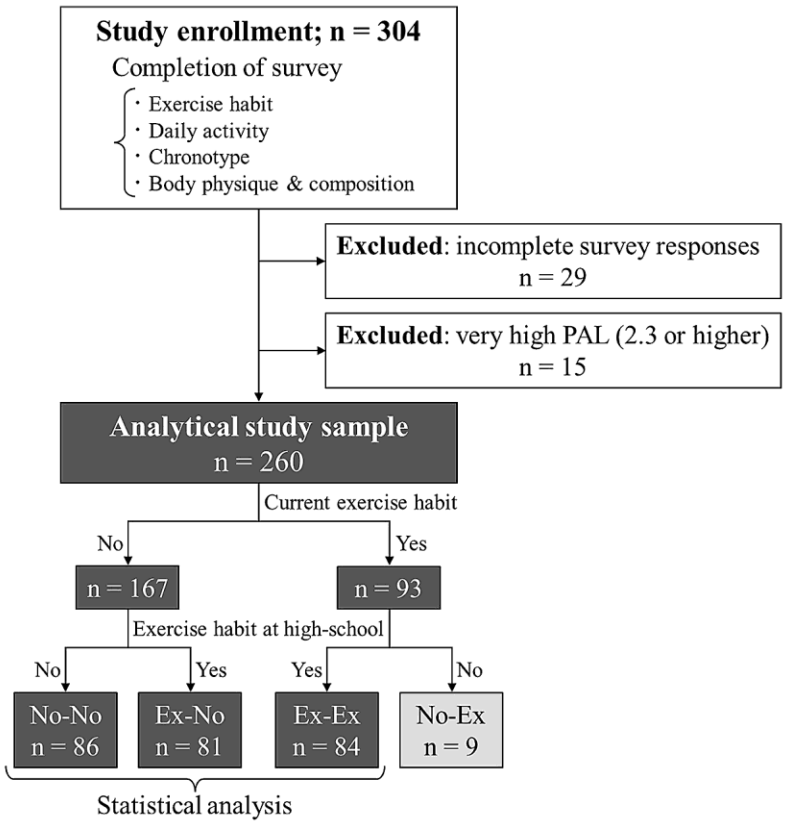

Figure 1. Flow diagram outlining selection of participants for this study.

Questionnaire-based survey and evaluation

Participants completed a questionnaire on their exercise habits, PA status, and chronotype.

Exercise habits and PAL

Two types of questions were asked regarding the participants' exercise habits. Current exercise habits were assessed using the following question: "*Do you exercise at least twice a week for more than 30 minutes each time, excluding sports activities in university classes*". Responses to this question were obtained by selecting 'yes' or 'no'. The participants' previous exercise habits were determined by answering the following question:

"*When you were in high school, did you exercise at least twice a week for at least 30 minutes at a time, excluding sports activities in high-school classes. Responses to this question were obtained by selecting 'yes' or 'no'.*"

Average daily activity and exercise time on weekdays during the previous month were assessed using a daily activity diary. The PAL of each activity was assessed by calculating the daily average of each classified activity using the product of the energy expenditure index, expressed as a multiple of basal metabolic rate (BMR) and activity time. This method was based on a study that estimated PAL according to the lifestyle of university students based on the "*Dietary Reference Intakes for Japanese people*" (Oshita and Myotsuzono 2021).

Chronotypes

The Japanese version (Ishihara et al. 1984) of the Horne and Ostberg (1976) Morningness-Eveningness Questionnaire (MEQ) was used to assess chronotypes. Individuals exhibiting a chronotype were classified as: definitely MT (score: 70–86) or moderately MT (score: 59–69), neither type (NT; score: 42–58), and moderately ET (score: 31–41) or definitely ET (score: 16–30) (Horne and Ostberg 1976). In the present study, definitively MT and moderately MT were classified as MT, and definitively ET and moderately ET as ET.

Body physique and composition

Body weight and body composition were measured using a body composition analyser (MC-780; Tanita, Japan) and employing the method of multi-frequency bioelectrical impedance analysis. Prior to these measurements, the participants were asked to remain in a seated resting position for 30 min. The participants were asked if they had any urination or bowel movements before the measurements. Subsequently, they wiped their palms and soles with alcohol-free wet wipes to moisten and clean the electrode contact areas, stepped onto the electrode section of the device, and grasped the hand electrodes with both palms. The results of the measurements included body weight, body mass index (BMI), body fat percentage (%BF), fat-free mass (FFM) and appendicular muscle mass (AMM), which were then used for analysis.

Statistical analyses

The mean and standard deviation (SD) of each variable were calculated for all participants. The Kruskal-Wallis test was used to compare variables between groups, and the Dunn-Sidak test was used for multiple comparisons. Additionally, the d-value was calculated as the effect size using Cohen's method. The proportions of participants that showed ET, NT, and MT in each group were also compared using the chi-squared test. The proportions of participants with BMI <18.5 kg/m^2, 18.5–24.9 kg/m^2, and ≥25 kg/m^2 in each group were compared using the chi-squared test. In addition, from the NW-O perspective, a chi-squared test was used to compare the proportions of participants in each group showing a BMI between 18.5 and 24.9 kg/m^2 with %BF of <30% and those with ≥30%. Although the criteria for %BF to assess NW-O vary and are not standardized, many studies have used a %BF of 30% in females (Wijayatunga and Dhurandhar 2021). Additionally, the V value was calculated as the effect size using Cramer's method.

The StatFlex statistical software (ver. 7.0.10; Artec, Osaka, Japan) was used for the aforementioned statistical procedures, with statistical significance level set at $p < .05$.

RESULTS

Measurements for all participants are shown in Table 1 (left), and those for each group are shown in Table 1 (right). Although height and weight were significantly higher in the EX-EX group than in EX-NO and NO-NO

groups, age and BMI were not significantly different among the groups. Regarding body composition, %BF of the EX-EX group was significantly lower (25.5 ± 5.5%) than that of EX-NO and NO-NO groups (28.9 ± 4.9% and 30.7 ± 5.7%, respectively), and FFM of the EX-EX group was significantly higher (42.1 ± 4.3 kg) than that of EX-NO and NO-NO groups (38.4 ± 4.1 and 35.9 ± 3.6 kg, respectively). In addition, FFM of the EX-NO group was significantly higher than that of NO-NO group. These effect sizes were moderate to large (d = 0.59–1.61). These results indicate that the individuals in the EX-EX group had lower body fat and higher muscle mass than those in EX-NO and NO-NO groups, although no differences in BMI were found. PAL was significantly higher in the EX-EX group (2.0 ± 0.2) than in EX-NO and NO-NO groups (1.7 ± 0.2 and 1.6 ± 0.2), with a large effect size (d ≥ 1.31). Although PAL was significantly lower in the NO-NO group than in EX-NO group, the effect size was small (d = 0.46). MEQ scores were significantly lower in the NO-NO group (44.3 ± 9.5) than in EX-EX and EX-NO groups (49.7 ± 9.2 and 47.6 ± 8.7), but the effect size was not large (d = 0.23–0.36).

Table 1. Means and standard deviations of parameters for all participants and for each group.

	ALL (n = 251)	EX-EX (n = 84)	EX-NO (n = 81)	NO-NO (n = 86)	Kruskal Wallis		Effect size (d)		
					H	*p*	Ex-Ex vs. Ex-No	Ex-Ex vs. No-No	Ex-No vs. No-No
Age (y)	18.8 ± 0.9	18.7 ± 0.6	18.9 ± 0.9	18.8 ± 1.1	1.5	.47	0.19	0.13	0.00
Height (cm)	158.2 ± 5.8	160.5 ± 5.9	158.0 ± 5.2*	156.4 ± 5.6*	18.3	<.01	0.45	0.70	0.00
Weight (kg)	54.3 ± 8.2	56.8 ± 8.1	54.3 ± 7.3	52.3 ± 8.6*	15.0	<.01	0.33	0.54	0.25
BMI (kg/m^2)	21.7 ± 2.7	22.0 ± 2.4	21.7 ± 2.4	21.4 ± 3.2	5.4	.07	0.12	0.23	0.13
%BF (%)	28.4 ± 5.7	25.5 ± 5.5	28.9 ± 4.9*	30.7 ± 5.7*	34.1	<.01	0.66	0.93	0.34
FFM (kg)	38.7 ± 4.7	42.1 ± 4.3	38.4 ± 4.1*	35.9 ± 3.6*†	72.6	<.01	0.86	1.54	0.66
AMM (kg)	17.1 ± 2.8	19.2 ± 2.6	16.7 ± 2.4*	15.5 ± 1.9*†	75.7	<.01	0.96	1.61	0.59
PAL	1.8 ± 0.3	2.0 ± 0.2	1.7 ± 0.2*	1.6 ± 0.2*†	90.6	<.01	1.31	1.68	0.46
MEQ	47 ± 9.4	49.7 ± 9.2	47.6 ± 8.7	44.3 ± 9.5*†	13.1	<.01	0.23	0.57	0.36

*Note. *; vs. EX-EX, †; vs. EX-NO, p < .05 (Dunn-Sidak test).*

Table 2 shows the chronotype classification for each group: the percentages of MT, NT and ET were 20.2%, 59.5% and 20.2%, respectively, in the EX-EX group; 11.1%, 60.5% and 28.4%, respectively, in the EX-NO group; and 9.3%, 53.5% and 37.2%, respectively, in the NO-NO group. The percentage of MT was significantly higher in the EX-EX group, whereas the percentage of ET was significantly lower in the EX-EX group and significantly higher in the NO-NO group.

Table 2. Number of participants of morning type (MT), Neither type (NT), and evening type (ET) in each group.

	Chronotype		
	MT	NT	ET
EX-EX	17▲ 20.2%	50 59.6%	17▼ 20.2%
EX-NO	9 11.1%	49 60.5%	23 28.4%
NO-NO	8 9.3%	46 53.5%	32▲ 37.2%

Note. $\chi^2(4) = 9.00$, p = .06, Cramer's V = 0.13. ▲ and ▼ significantly higher and lower (residual analysis).

Table 3 shows the classification of BMI in each group. Most of the participants in each group had a BMI between 18.5 and 24.9 kg/m^2 (≥78%), and results of the chi-squared test showed no significant differences. Table 4 shows the distribution of %BF for participants in each group with a BMI between 18.5 and 24.9 kg/m^2. The percentages of those with %BF <30% and ≥30% were 90.4% and 9.6%, respectively, in the EX-EX

group; 59.7% and 40.3%, respectively, in the EX-NO group; and 49.3% and 50.72%, respectively, in the NO-NO group. Although the number of participants with %BF <30% was significantly lower in the EX-EX group, that with %BF ≥30% was significantly higher in the NO-NO group.

Table 3. Number of participants in each group with BMI <18.5 kg/m^2, 18.5–24.9 kg/m^2, and ≥25.0 kg/m^2.

	BMI (kg/m^2)		
	<18.4	**18.5-24.9**	**≥ 25.0**
EX-EX	1 1.2%	73 86.9%	10 11.9%
EX-NO	6 7.4%	67 82.70%	8 9.9%
NO-NO	8 9.3%	71 82.6%	7 8.1%

Note. $\chi^2(4) = 5.82$, $p = .21$, Cramer's $V = 0.11$.

Table 4. Number of participants with body fat <30.0% and ≥30.0% among those with BMI between 18.5 and 24.9 kg/m^2 in each group.

	%BF (%)	
	<30.0	**≥30.0**
EX-EX	66▲ 90.4%	7▼ 9.6%
EX-NO	40 59.7%	27 40.3%
NO-NO	35▼ 49.3%	36▲ 50.7%

Note. $\chi^2(4) = 29.69$, $p < .01$, Cramer's $V = 0.38$. ▲ and ▼ significantly higher and lower (residual analysis).

DISCUSSION

The results of this study showed that the Ex-Ex group had significantly higher PAL than EX-NO and NO-NO groups. Consequently, the EX-EX group had higher FFM or AMM and lower %BF, and the effect sizes were moderate to large. This is consistent with a previous study showing that even if female university students had a habit of exercising in high school, they had lower muscle mass if their current PAL was low (Oshita and Myotsuzono 2021). Therefore, these results suggest that current exercise habits are a contributing factor to appropriate body composition. In contrast, neither the participants in the NO-NO nor in EX-NO groups had current exercise habits, and although there was a significant difference in PAL, the effect size was small. However, FFM and AMM were significantly lower in the EX-NO group than in the EX-EX group and the effect size was moderate. A study on women aged 18-28 years reported that exercise habits at 7 years of age or older had a positive effect on muscle mass (Ayabe et al. 2019). In the present study, the NO-NO group did not have the opportunity to consistently gain higher muscle mass from the past to the present, which may have resulted in the differences in FFM and AMM between the NO-NO and EX-NO groups.

Regarding association with chronotypes, no significant differences in MEQ scores were found between the EX-EX and EX-NO groups. A previous review had shown an inconsistent relationship between PA and chronotypes in university students (Sempere-Rubio et al. 2022). The present study also showed that university students who had exercised in high school (i.e., the EX-EX and EX-NO groups) did not differ in chronotypes according to their current exercise habits. In contrast, both the NO-NO and EX-NO groups did not have current exercise habits, although the NO-NO group had significantly lower MEQ scores. A relationship between lower PAL and later chronotype has also been observed in children and adolescents (Huang et al. 2024). Therefore, the specific chronotype (e.g., ET of MT) shown owing to previous PA may

not be fully modified by current PA. This may explain why the relationship between the chronotype and PA observed in the mid-twenties is not consistent in university students.

As the current study is a cross-sectional study, the causal relationship between PA and chronotype is not known. Therefore, it is not known whether exercise habits influence an individual's morning chronotype or whether the morning chronotype has an advantage in establishing one's exercise habits. A previous study on circadian phase (not chronotypes) showed that exercise in young adults with ET advanced the circadian phase regardless of the time of exercise (Thomas et al. 2020). Furthermore, light exercise in the morning in inactive adolescents with a later chronotype (Lang et al. 2022) and a gradual earlier exercise schedule among them (Richardson et al. 2017) have been suggested to advance the circadian phase. Although the mechanism between PA and circadian rhythm is not known, moderate exercise during the day has been suggested to promote adjustment of circadian rhythm, similar to stimulation with light (Hower et al. 2018). Therefore, depending on the time of exercise, exercise habits may advance their circadian phase, making them more likely to adapt to a morning-oriented culture.

The participants in the NO-NO group had lower MEQ scores, with approximately 40% of them being ET in this study. Although the present study focused on exercise habits, previous studies have reported an association between ET and other lifestyle behaviours. In terms of diet, an individual of ET was more likely to skip breakfast or consume fewer calories during breakfast, while consuming more calories during dinner and snacks in the afternoon or at night (Mazri et al. 2019; van der Merwe et al. 2022; Baldan and Ozcelik-Ersu 2024). Furthermore, irregular meal patterns were also found to be associated with later chronotype in university students (Nishimura et al. 2023). An association between chronotype and sleep problems has also been reported. Social jetlag (SJL) is the difference in the midpoint of sleep between work/school days and free days; a later chronotype has been found to be associated with an increase in SJL, and females may be at a higher risk of developing adverse health symptoms because they have a higher SJL than males (Kodama et al. 2019). Furthermore, a recent report has shown that an increase in SJL is associated with lower PA in female Japanese students (Shibata et al. 2024). Although the present study found no significant difference in exercise habits based on BMI classification, more than half of the participants in the NO-NO group with normal BMI had a high %BF (≥30%). These findings indicate that individuals who did not have exercise habits throughout their past may have an imbalance in the body composition not only due to energy expenditure from physical activity, but also due to lifestyle differences because of them being ET. Therefore, individuals with no exercise habits in the past may require lifestyle modification according to their chronotype to achieve appropriate body composition.

This study has some limitations. First, this is a cross-sectional study, and future longitudinal studies are needed to investigate whether changes in PA are associated with changes in chronotypes. In particular, it would be interesting to evaluate in what way the chronotypes change when individuals with no previous exercise habits later develop an exercise habit. Although the NO-EX group was excluded from the analysis in this study because of the small number of participants, future studies should include this type of participants. Second, the exercise habits examined in this study did not investigate the time of day at which participants exercised. A previous study has suggested that evening exercise in MT delays the circadian phase (Thomas et al. 2020). Furthermore, another study has reported that evening exercise in adolescents may delay the circadian phase (Richardson et al. 2017). However, a study on sleep patterns indicated that evening exercise may advance sleep onset and wake time, and that there is no association between sleep duration or sleep quality and pre-sleep exercise (Kahn et al. 2021). Therefore, although the relationship between the time of exercise and sleep-wake cycle may be weak, future studies may elucidate the relationship between exercise habits and chronotypes, including the time of exercise. Finally, the present

study was based on a questionnaire; however, sleep-wake rhythms and physical activity should be assessed using objective methods (e.g., using an activity monitor).

CONCLUSION

This study investigated the relationship between exercise habits in university and high school and chronotypes and body composition among female university students. Participants with exercise habits in high school and university had significantly lower %BF and significantly higher %FFM than those without exercise habits in university. Although participants without exercise habits in high school and university had significantly lower FFM than those with exercise habits in high school only (without current exercise habits), there was no significant difference in %BF. Furthermore, more than half of the students without consistent exercise habits had a %BF ≥ 30% despite a normal BMI range, which accounted for a significantly higher proportion. Regarding the chronotypes, students with consistent exercise habits showed a significantly higher MT and significantly lower ET. However, students without consistent exercise habits had significantly lower MEQ scores than the other groups; approximately 40% were ETs, accounting for a significantly higher proportion. These results indicate that female university students with consistent exercise habits from high school were fewer in the ET category. These results suggest that current and past exercise habits of university students are related to specific chronotypes (e.g., ET or MT), and that fewer students with consistent exercise habits in high school belong to the ET category, while more students (approximately 40%) without consistent exercise habits belong to the ET category. Furthermore, students without consistent exercise habits were more likely to be normal-weight obesity.

AUTHOR CONTRIBUTIONS

IY and OK designed this study and interpreted the data. IY, OK, SK, MR and NK collected and analysed the data. IY and OK was a major contributor to writing the manuscript, and SK, MR and NK substantively revised it. The authors read and approved the final manuscript.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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