Association between Social Jetlag and Objective Physical Activity among Female University Students of Japan: A Cross-Sectional Study

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Abstract

Objective Discrepancies between sleep timing on work/school and free days, also known as social jetlag (SJL), can cause health problems. These issues occur most often in individuals from adolescence to the early 20s, which is equivalent to the age of university students. This study was designed to explore the recommended level of physical activity required to minimize SJL and to examine the relationship between SJL and objective physical activity among female university students.

Methods We assessed the SJL of 68 female students using the Japanese version of the Munich Chronotype Questionnaire. The objective physical activity and sleep variables of subjects were also evaluated at 3 to 4 weeks using a small triaxial accelerometer.

Results A significant negative correlation was found between SJL and physical activity on both free ($r = -0.435$, $p < 0.001$) and school days ($r = -0.341$, $p < 0.01$). According to the linear regression analysis, physical activity of 11,174 steps on school days and 10,713 steps on free days had the lowest SJL value. Total sleep time on free days had a significant positive correlation with SJL ($r = 0.399$, $p < 0.001$) and a negative correlation with physical activity ($r = -0.520$, $p < 0.001$).

Discussion Our results suggest that substantial SJL may cause chronic fatigue and lead to a low level of physical activity in female university students. These results also imply that the recommended level of physical activity necessary to minimize SJL among these students is around 11,000 steps on both school and free days.

Keywords
- social jetlag
- physical activity
- circadian rhythm
- university students

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Introduction

Social jet lag (SJL), defined as the difference in the midpoint of sleep between work/school days and free days, is the discrepancy between circadian rhythms and life rhythms dictated by social constraints.[1,2] Travel-induced jet lag symptoms, such as malaise, drowsiness, and difficulty concentrating, caused by high-speed intercontinental travel on passenger jets, are temporary. However, SJL has been associated with chronic health hazards, including obesity, metabolic diseases such as type 2 diabetes,[3–5] increased risk of depression,[6] smoking, and excessive caffeine intake.[1] Social jetlag is most prevalent from adolescence to the early 20s,[3] with 63.7% of university students reportedly having SJL of $\geq$ 2 hours.[7] In addition, a study of SJL in university students showed that greater SJL was associated with worse academic performance,[8,9] lower quality of life,[9] and more severe menstrual symptoms.[10] Thus, alleviating SJL in university students is a significant health objective.

Bright light is considered the essential synchronizer of circadian rhythms.[11,12] Additionally, social schedules, such as diet[13] and physical activity,[12–16] have also been shown to be important synchronizers. Among university students, increased physical activity was associated with greater life satisfaction and happiness,[17] whereas longer sedentary time increased stress, depressive tendencies, and anxiety.[18] Thus, clarifying the relationship between physical activity and SJL is important to lead a healthy life, but few studies have reported the relationship between SJL and physical activity for university students using objective indices. Subjective physical activity was reportedly lower in a group with SJL of $\geq$ 2 hours than in a group with SJL of $\leq$ 1 hour.[4] Also, a negative correlation has been reported between subjective physical activity and SJL[19] in night shift workers. However, the recommended level of objective physical activity that minimizes SJL has not yet been mentioned.

The recent survey on SJL for a large Japanese population[20] showed that absolute SJL was higher in female participants than that in male participants. Symptoms of depression are reportedly more common in female students than in male students among adolescents, including college students.[21] Furthermore, previous studies have shown that physical activity in female university students was lower than that in male university students[22]; especially on free days, female university students showed a considerable decrease in physical activity.[23] Thus, it can be inferred that lower physical activity among female university students, especially on free days, may be associated with SJL and health problems. Therefore, in this study, to explore the recommended level of physical activity needed to minimize SJL, we evaluated female university students using objective indices of physical activity and nocturnal sleep to determine the relationship with SJL.

Materials and Methods

Participants

Students with regular weekly schedules were recruited for the study via advertisements on university bulletin boards. Participants were recruited while considering appropriate exclusion criteria to eliminate the effects of smoking, drinking, medications, and high-intensity competitive sports. Initially, 71 female university students were enrolled in this study, but 3 were eventually excluded for lack of appropriate cooperation. Therefore, data from 68 participants were included in the final analysis. The sample was homogenous with respect to age (20.5 ± 1.5 years), weight (51.1 ± 6.3 kg), height (1.57 ± 0.05 m), body mass index (BMI) (20.7 ± 2.6 kg/m^2), and social situation (students belonging to the same university). All subjects were healthy and had no history of sleep disorders. The study protocol was approved for an exemption by the Research Ethics Committee of the College of Nursing Art and Science, University of Hyogo (institutional review board approval number: 2018-F17). The study objectives and methods and the expected advantages and disadvantages of participation were explained to the students, and written consent was obtained from all participants. It has been reported that premenstrual sleep quality is slightly poorer, but the size of the difference is of little clinical significance,[24] and that sleep and exercise behavior remain constant regardless of menstrual cycle.[25] For these reasons, we did not investigate the menstrual cycle of the participants.

Measurements

Chronotype and SJL

The Japanese version of the Munich Chronotype Questionnaire (MCTQ)[26] was used to estimate chronotypes and SJL. The MCTQ included questions about shift work, the number of work/school and free days during the week, and bed and wake times, including sleep/wake latency on work/school and free days. The validity of the Japanese version of the MCTQ has been shown in a previous report by Kitamura et al.[26]

Chronotype, an individual's preference for sleep timing, was assessed using mid-sleep time on free days corrected for sleep debt on work days (MSFsc).[27] As a behavioral indicator of circadian misalignment, SJL was calculated as the absolute difference between the midpoint of sleep on work and free days, based on the study by Wittmann et al.[1]

Objective Physical Activity and Sleep Parameters

All subjects were asked to wear a small triaxial accelerometer (MTN-220, ACOS, Japan; diameter 27 mm, thickness 9 mm, weight 9 g, including batteries) around the left hip for 3 to 4 weeks, at all times except when bathing, and to record their morning wake times and bedtimes in a sleep diary. The number of steps taken was employed as a quantitative parameter for daily physical activity, and the mean number of steps on school and free days taken from waking up to bedtime was recorded. Some previous studies on physical activity in university students have shown a high incidence of sedentary time, primarily on weekend days.[22,23] Since it has also been suspected that SJL is expressed as the difference between physical activity on school days and free days, as an indicator of physical activity associated with SJL, the ratio between steps taken on free days and on school days was calculated in this study.

Previous studies have shown that adults aged 19 to 65 years with shorter sleep duration have higher SJL.[28] In this study, we measured the objective sleep variables of participants and examined the relationship between sleep variables and SJL or physical activity. Sleep-wake scoring algorithm software (Sleep-Sign-Act version 2.0, KISSEI COMTEC CO., LTD., Matsumoto, Nagano, Japan) was used to analyze the activity data obtained from the small triaxial accelerometer together with wake times and bedtimes from the sleep diary to calculate the following sleep parameters: total sleep time (TST), sleep latency (SL), waking after sleep onset (WASO), and sleep efficiency (SE).[29] Validation of the accuracy and convenience of this method has been previously described.[29,30] Sleep parameter analysis was performed based on whether the next day was a school day or a free day. Physical activity and objective sleep data were considered valid if participants had a minimum accelerometer wear time of 10 days, with around 23 hours per day.

Data Analysis

All data were initially recorded in a Microsoft Excel spreadsheet (Microsoft Corp., Redmond, WA, USA) and later transferred to the Japanese version of the SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY USA) for statistical analysis. The normality of distributions was assessed using the Shapiro–Wilk normality test. All variables met the assumption of normality, except a part of sleep variables (e.g., SL and SE). Values were presented as mean ± standard deviation (SD). For each variable, 95% confidence intervals (CIs) were calculated. A paired t-test was used to compare the physical activity data and midpoint of sleep between school days and free days. Pearson correlations were performed between each measure of MSFsc, SJL, and physical activity data. A linear regression analysis was performed when the linear association between SJL and physical activity was significant, and the physical activity that minimized SJL was calculated from the regression equation. In other words, y (steps) was calculated by substituting x (SJL) with 0 in the linear regression equation. Wilcoxon signed-rank test was used to compare the sleep variables between school days and free days. The Spearman correlation coefficient was used for the correlation analysis between sleep and other variables. The level of significance was set at $p < 0.05$.

Results

Chronotype and SJL

As shown in ►**Table 1**, the average midpoint of sleep on free days (5:05 ± 1:00) was significantly ($p < 0.001$) later than that on school days (3:46 ± 0:47). The mean SJL was 1:18 ± 0:35 (95% CI, 1:09–1:27), and 76.5% participants had SJL of ≥ 1 hour. None of the participants showed a negative SJL value. As the average MSFsc of participants was 4:32 ± 0:56 (95% CI: 4:19–4:36), their mean chronotype was estimated as "slightly late"[2]. Hence, a significant positive correlation ($r = 0.475$; $p < 0.001$) was found between MSFsc and SJL.

Objective Physical Activity and Sleep Variables

The average number of valid data days was 21.3 ± 6.8, and 91.9% of participants obtained valid data by properly wearing the small triaxial accelerometers for more than 2 weeks. ►**Table 1** compares the objective physical activity and the sleep parameters between school days and free days. The number of steps on free days was significantly lower than on school days, and the average ratio of steps taken on free days to those taken on school days was 86 ± 27% (95% CI, 80–93). On free days, the TST was significantly longer ($t = 9.65$; $p < 0.001$) and SE was significantly higher ($t = 3.41$; $p < 0.01$) than those on school days. No differences were observed between school days and free days for SL and WASO.

Table 1 Comparison of objective physical activity, midpoint of sleep, and sleep variables between school and free days.

Variable	School days (95% CI)	Free days (95% CI)	*p*
PA, steps per day	9,030 ± 2,867 (8,336–9,724)	7,718 ± 3,147 (6,956–8,479)	< 0.001*
Midpoint of sleep, h:min	3:46 ± 0:47 (3:34–3:58)	5:05 ± 1:00 (4:50–5:20)	< 0.001*
TST, min	349 ± 49 (337–362)	424 ± 72 (406–442)	< 0.001*
SL, min	18 ± 10 (15–20)	17 ± 9 (14–19)	0.28
WASO, min	49 ± 25 (48–55)	53 ± 25 (47–60)	0.06
SE, %	82.7 ± 6.6 (81.0–84.3)	84.4 ± 6.1 (82.9–86.0)	< 0.01*

Abbreviations: PA, physical activity; SE, sleep efficiency; SL, sleep latency; TST, total sleep time; WASO, waking after sleep onset.
Data presented as mean ± SD (95% CI).
*Significant difference at $p < 0.05$.

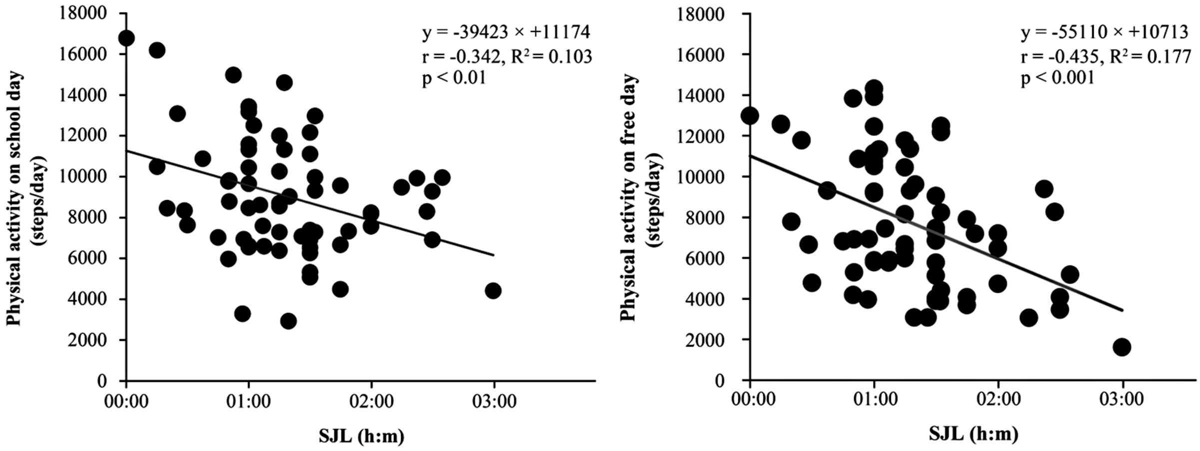

Fig. 1 Relationship between social jetlag and physical activity on school days (left) and free days (right) (n = 68).

Relationship between SJL, Physical Activity, and Sleep Variables

As shown in ►**Figure 1**, there was a significant negative correlation between SJL and physical activity on school days (r = – 0.342, 95% CI; 9,583–12,764 steps, $p < 0.01$, adjusted $R^2 = 0.103$) and on free days (r = – 0.435, 95% CI; 9,041–12,386 steps, $p < 0.001$, adjusted $R^2 = 0.177$). The physical activity with 11,174 steps on school days and 10,713 steps on free days had the lowest SJL value (0:00) based on the linear regression analysis of SJL and physical activity. Social jetlag also showed a significant negative correlation (r = – 0.271; 95% CI, 0.87–1.18, $p < 0.05$, adjusted $R^2 = 0.059$) with the ratio of steps on free days to school days (►**Fig. 2**). Total sleep time on free days had a significant positive correlation with SJL (r = 0.399; $p < 0.001$), and negative correlation with physical activity on free days (r = – 0.520, $p < 0.001$) and the ratio of steps on free days to school days (r = – 0.305; $p < 0.05$). There was a significant positive correlation (r = 0.292; $p < 0.05$) between SL on school days and SJL. Other sleep variables were not significantly associated with SJL and physical activity.

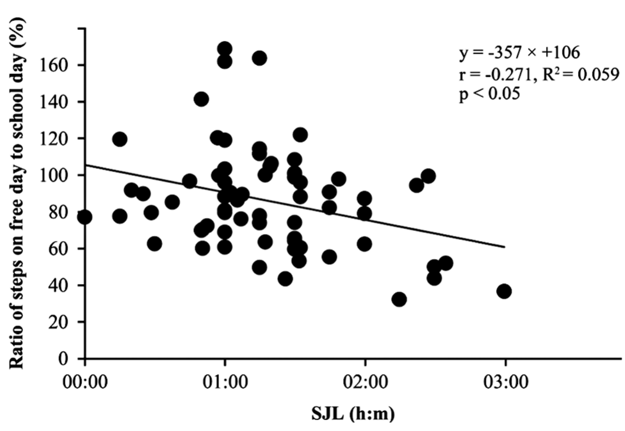

Fig. 2 Relationship between social jetlag and the ratio of steps between free days and school days (n = 68).

Discussion

In this study, SJL and the chronotypes of female university students were evaluated using the MCTQ. Relationships were investigated using objective methods to obtain physical activity and sleep indices. The results of this study revealed that SJL and physical activity were significantly negatively associated not only on school days but also on free days. Social jetlag also showed a significant, weak, negative correlation with the ratio of steps taken on free days to those taken on school days.

The mean ± SD chronotype MSFsc in this study was 4:32 ± 0:56, which was almost the same as that reported in a previous study conducted in Japanese women of comparable age.[20] In addition, the proportion of those with SJL ≥ 1 hour shown in a previous study involving 150 female university students in Japan[10] was 78%, which was similar to the results in this study (76.5%). The correlation coefficient between MSFsc and SJL obtained in this study (r = 0.475) was similar to that obtained in a previous study conducted on 228 university students (82.5% females, r = 0.516).[31] Furthermore, the mean number of steps on free days in this study was 7,718, which was slightly higher than the results of a recent study of female university students in Portugal (mean 6,474 steps, n = 73)[22] but similar to the results of a study in Spain (mean 7,656 steps, n = 206).[23] Moreover, the mean number of steps on school days in this study was 9,030, which was almost the same as reported in previous studies.[22,23] Thus, the chronotypes, SJL, and physical activity of the participants in this study appeared to be standard for female university students.

In this study, SJL was negatively and significantly associated with objective physical activity on school days and free days. In a previous study[4] that investigated the relationship between subjectively assessed physical activity using a questionnaire and SJL in generally healthy volunteers, physical activity was lower in a group with a large SJL of ≥ 2 hours than in a group with SJL of ≤ 1 hour. One explanation for this phenomenon is that SJL causes chronic fatigue and drowsiness,[32] resulting in low physical activity due to devoting time to resting.[19] In actuality, this study also found a weak but significant positive association between SJL and TST on free days, demonstrating that female university students with larger SJL sleep more on free days, as measured by objective sleep indices. In addition, a study on the relationship between SJL and physical activity in late-night shift workers (work hours: 17:00–03:00) showed a negative correlation for both indices.[19] Late-night shift workers are considered to have chronic fatigue and excessive sleepiness; however, female university students with large SJL in this study were also likely to experience chronic fatigue. Thus, these students were thought to sleep longer on free days to recover from fatigue.

A new result from this study showed the ratio of steps on free days to that on school days to be weakly and significantly negatively associated with SJL and also weakly and significantly positively associated with TST on free days. In general, university students have lower activity levels on free days than on school days.[22,23,33] However, this difference in physical activity between school and free days can be interpreted as a manifestation of SJL. Thus, it was considered reasonable that the students whose number of steps on free days was lower than that on school days had more SJL and longer TST on free days. In contrast, although there was no significant correlation between step count ratio and SJL on TST on school days, this result was inferred to be due to social schedule constraints. From the regression analysis of SJL and physical activity in this study, the number of steps at which SJL became the minimum (0:00) was 11,174 steps on school days and 10,713 steps on free days, which was close to the recommended daily physical activity of 10,000 steps for maintaining good health.[33] This value was calculated from the mean number of valid measurement days (21.3) and was based on objective data that more adequately reflected the university students' daily lives, including free days. Many previous studies relied on objective indices of physical activity for university students. These investigations used measurement data from 7 consecutive days,[22,23] whereas the measurement period in this study was about 3 times longer and, hence, considered sufficient.

The impact of SJL on the life of university students appears to be serious. A previous study of SJL in 346 female university students[9] reported that an increase in SJL was associated with decreased quality of life. Additionally, a previous study[10] involving 150 female university students showed an association between SJL of $\geq$ 1 hour and severe menstrual symptoms. Moreover, SJL has a negative impact on academic performance.[8,9] These findings suggest the need for intervention to address the issue.

Social schedules, bright light,[11,12] diet,[13] and physical activity[12,14–16] are thought to be synchronizers of external and internal rhythms. Among these, physical activity has been shown to affect the mental health of university students positively. For example, a study[17] that surveyed the life satisfaction, happiness, perceived health status, and physical activity of 12,492 university students in 24 countries reported that moderate or high-intensity physical activity was associated with greater life satisfaction, happiness, and views on health. Furthermore, a study on the relationship between sedentary behavior and mental health in 244 university students[18] showed that increased sedentary time was associated with increased stress, anxiety, and depression. Thus, increased physical activity and decreased sedentary time have been suggested to positively affect the mental health of university students. As this is a cross-sectional study, causal relationships for both SJL and physical activity indices cannot be discussed. However, increased physical activity, particularly on free days, may have a positive impact on reducing SJL. In actuality, SJL is considered a measure of stress resulting from the discordance between external and internal rhythms.[21]

This study has a few limitations. We measured steps taken by female university students as a quantitative parameter for daily physical activity. Steps are a good indicator to assess the quantity of daily activity but not the quality of physical activity. Further, our results cannot be extrapolated to a larger population because this study included only young female subjects. Future studies are required to compare results with a male population and accumulate data on SJL mitigation through intervention studies to increase physical activity.

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Conflict of Interests
The authors have no conflict of interests to declare.

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References

1 Wittmann M, Dinich J, Merrow M, Roenneberg T. Social jetlag: misalignment of biological and social time. Chronobiol Int 2006; 23(1-2):497–509. Doi: 10.1080/07420520500545979
2 Roenneberg T, Pilz LK, Zerbini G, Winnebeck EC. Chronotype and social jetlag: A (self-) critical review. Biology (Basel) 2019;8(03): 54. Doi: 10.3390/biology8030054
3 Roenneberg T, Allebrandt KV, Merrow M, Vetter C. Social jetlag and obesity. Curr Biol 2012;22(10):939–943. Doi: 10.1016/j.cub.2012.03.038
4 Rutters F, Lemmens SG, Adam TC, et al. Is social jetlag associated with an adverse endocrine, behavioral, and cardiovascular risk profile? J Biol Rhythms 2014;29(05):377–383. Doi: 10.1177/0748730414550199
5 Parsons MJ, Moffitt TE, Gregory AM, et al. Social jetlag, obesity and metabolic disorder: investigation in a cohort study. Int J Obes 2015;39(05):842–848. Doi: 10.1038/ijo.2014.201
6 Levandovski R, Dantas G, Fernandes LC, et al. Depression scores associate with chronotype and social jetlag in a rural population. Chronobiol Int 2011;28(09):771–778. Doi: 10.3109/07420528.2011.602445
7 Tavares PS, Carpena MX, Carone CMM, Del-Ponte B, Santos IS, Tovo-Rodrigues L. Is social jetlag similar to travel-induced jetlag? Results of a validation study. Chronobiol Int 2020;37(04): 542–551. Doi: 10.1080/07420528.2020.1712413

8 Haraszti RÁ, Ella K, Gyöngyösi N, Roenneberg T, Káldi K. Social jetlag negatively correlates with academic performance in undergraduates. Chronobiol Int 2014;31(05):603–612. Doi: 10.3109/07420528.2013.879164

9 Chang SJ, Jang SJ. Social jetlag and quality of life among nursing students: A cross-sectional study. J Adv Nurs 2019;75(07): 1418–1426. Doi: 10.1111/jan.13857

10 Komada Y, Ikeda Y, Sato M, Kami A, Masuda C, Shibata S. Social jetlag and menstrual symptoms among female university students. Chronobiol Int 2019a;36(02):258–264. Doi: 10.1080/07420528.2018.1533561

11 Dewan K, Benloucif S, Reid K, Wolfe LF, Zee PC. Light-induced changes of the circadian clock of humans: increasing duration is more effective than increasing light intensity. Sleep 2011;34(05): 593–599. Doi: 10.1093/sleep/34.5.593

12 Youngstedt SD, Kline CE, Elliott JA, Zielinski MR, Devlin TM, Moore TA. Circadian phase-shifting effects of bright light, exercise, and bright light + exercise. J Circadian Rhythms 2016;14:2. Doi: 10.5334/jcr.137

13 Wehrens SMT, Christou S, Isherwood C, et al. Meal timing regulates the human circadian system. Curr Biol 2017;27(12): 1768–1775.e3. Doi: 10.1016/j.cub.2017.04.059

14 Van Reeth O, Sturis J, Byrne MM, et al. Nocturnal exercise phase delays circadian rhythms of melatonin and thyrotropin secretion in normal men. Am J Physiol 1994;266(6 Pt 1):E964–E974. Doi: 10.1152/ajpendo.1994.266.6.e964

15 Miyazaki T, Hashimoto S, Masubuchi S, Honma S, Honma KI. Phase-advance shifts of human circadian pacemaker are accelerated by daytime physical exercise. Am J Physiol Regul Integr Comp Physiol 2001;281(01):R197–R205. Doi: 10.1152/ajpregu.2001.281.1.r197

16 Youngstedt SD, Elliott JA, Kripke DF. Human circadian phase-response curves for exercise. J Physiol 2019;597(08):2253–2268. Doi: 10.1113/JP276943

17 Pengpid S, Peltzer K. Sedentary behaviour, physical activity and life satisfaction, happiness and perceived health status in university students from 24 countries. Int J Environ Res Public Health 2019;16(12):2084. Doi: 10.3390/ijerph16122084

18 Lee E, Kim Y. Effect of university students' sedentary behavior on stress, anxiety, and depression. Perspect Psychiatr Care 2019;55 (02):164–169. Doi: 10.1111/ppc.12296

19 Alves MS, Andrade RZ, Silva GC, et al. Social jetlag among night workers is negatively associated with the frequency of moderate or vigorous physical activity and with energy expenditure related to physical activity. J Biol Rhythms 2017;32(01):83–93. Doi: 10.1177/0748730416682110

20 Komada Y, Okajima I, Kitamura S, Inoue Y. A survey on social jetlag in Japan: a nationwide, cross-sectional internet survey. Sleep Biol Rhythms 2019b;17:417–422. Doi: 10.1007/s41105-019-00229-w

21 de Souza CM, Hidalgo MPL. Midpoint of sleep on school days is associated with depression among adolescents. Chronobiol Int 2014;31(02):199–205. Doi: 10.3109/07420528.2013.838575

22 Clemente FM, Nikolaidis PT, Martins FML, Mendes RS. Physical activity patterns in university students: Do they follow the public health guidelines? PLoS One 2016;11(03):e0152516. Doi: 10.1371/journal.pone.0152516

23 Arias-Palencia NM, Solera-Martínez M, Gracia-Marco L, et al. Levels and patterns of objectively assessed physical activity and compliance with different public health guidelines in university students. PLoS One 2015;10(11):e0141977. Doi: 10.1371/journal.pone.0141977

24 Romans SE, Kreindler D, Einstein G, Laredo S, Petrovic MJ, Stanley J. Sleep quality and the menstrual cycle. Sleep Med 2015;16(04): 489–495. Doi: 10.1016/j.sleep.2014.12.001

25 Pierson E, Althoff T, Thomas D, Hillard P, Leskovec J. Daily, weekly, seasonal and menstrual cycles in women's mood, behaviour and vital signs. Nat Hum Behav 2021;5(06):716–725. Doi: 10.1038/s41562-020-01046-9

26 Kitamura S, Hida A, Aritake S, et al. Validity of the Japanese version of the Munich ChronoType Questionnaire. Chronobiol Int 2014;31 (07):845–850. Doi: 10.3109/07420528.2014.914035

27 Roenneberg T, Kuehnle T, Juda M, et al. Epidemiology of the human circadian clock. Sleep Med Rev 2007;11(06):429–438. Doi: 10.1016/j.smrv.2007.07.005

28 Almoosawi S, Palla L, Walshe I, Vingeliene S, Ellis JG. Long sleep duration and social jetlag are associated inversely with a healthy dietary pattern in adults: Results from the UK national diet and nutrition survey rolling programme Y1–Y4. Nutrients 2018;10 (09):1131. Doi: 10.3390/nu10091131

29 Enomoto M, Endo T, Suenaga K, et al. Newly developed waist actigraphy and its sleep/wake scoring algorithm. Sleep Biol Rhythms 2009;7:17–22. Doi: 10.1111/j.1479-8425.2008.00377.x

30 Matsuo M, Masuda F, Sumi Y, et al. Comparisons of portable sleep monitors of different modalities: Potential as naturalistic sleep recorders. Front Neurol 2016;7:110. Doi: 10.3389/fneur.2016.00110

31 Jokubauskas L, Baltrušaitytė A, Pileičikienė G, Žekonis G. Interrelationships between distinct circadian manifestations of possible bruxism, perceived stress, chronotype and social jetlag in a population of undergraduate students. Chronobiol Int 2019;36 (11):1558–1569. Doi: 10.1080/07420528.2019.1660356

32 Juda M, Vetter C, Roenneberg T. Chronotype modulates sleep duration, sleep quality, and social jet lag in shift-workers. J Biol Rhythms 2013;28(02):141–151. Doi: 10.1177/0748730412475042

33 Sigmundová D, Chmelík F, Sigmund E, Feltlová D, Frömel K. Physical activity in the lifestyle of Czech university students: Meeting health recommendations. Eur J Sport Sci 2013;13(06): 744–750. Doi: 10.1080/17461391.2013.776638

