Journal of Exercise Science & Fitness 22 (2024) 221–226

Contents lists available at ScienceDirect

Journal of Exercise Science & Fitness

journal homepage: www.elsevier.com/locate/jesf

Associations between levels of physical literacy and adherence to the 24-h movement guidelines among university students: A cross-sectional study

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ARTICLE INFO

Keywords:
Physical literacy
China
24-H movement guideline
Young adults
Associations

ABSTRACT

Objectives: Emerging evidence indicates that the composition of movement behaviours within a 24-h period is associated with multiple health benefits across the lifespan. A concept that emphasises an individual's active lifestyle is physical literacy (PL), yet empirical research exploring the potential associations between PL and 24-h movement guidelines remains scarce. This study aimed to evaluate the associations between levels of PL and adherence to the guidelines among Chinese university students.

Study design: A cross-sectional study.

Methods: Seven hundred and ninety-eight university students (390 male, 19.2 ± 1.2 years) completed all the measurements. Levels of PL and participants' adherence to guidelines including physical activity, sedentary behaviour and sleep were self-reported through Perceived Physical Literacy Instrument, International Physical Activity Questionnaire and Pittsburgh Sleep Quality Index, respectively. Two-way ANOVA was conducted to determine the associations between the number of guidelines met (0, 1, 2, or 3) and levels of PL.

Results: The results demonstrate that 36.5% (n = 291) of the participants met all the three guidelines, while 4.1% (n = 33) met none. Further analysis indicated that meeting physical activity or sedentary behaviour guidelines was associated with significantly higher total PL scores, and scores in the sub-domains of Confidence and Physical Competence and Motivation.

Conclusions: The findings provide evidence that young adults who obtained higher PL scores may meet more guidelines during a 24-h period. Future studies should incorporate accelerometer-based physical activity measurements and investigate the causal relationship between PL and adherence to the movement guidelines.

1. Introduction

From a movement perspective, a 24-h period includes a continuous integration of physical activity (PA), sedentary behaviour (SB), and sleep behaviours, representing a holistic framework of an individual's health. Co-development of three behaviour patterns is advocated to achieve optimal health benefits throughout the lifespan.[1–4] To inform a healthier 24-h circle, the Canadian 24-h Movement Guidelines for adults was released in 2020, which requires any individuals to accumulate at least 150 min of moderate-to-vigorous PA (MVPA), engage in less than 8 h of SB and sleep for a duration of 7–9 h.[5]

Evidence from research has indicated a decline in PA participation as people gradually transit from adolescence to early adulthood.[6,7] For example, it has been found that university students as the emerging adults have engaged in at least 5-min less of MVPA per day compared to their adolescent years.[6] Their time spent in SB, as measured by accelerometers, has increased up to 9 h daily and found to have detrimental effects on health outcomes.[7] In addition, a report combining data from 26 countries has found that 39.2% of undergraduates have slept less than 6 h per day.[8] Importantly, university students in China are frequently reported as undertaking insufficient PA, engaging in prolonged SB, and experiencing poor sleep quality.[9,10] This is concerning as compliance with the 24-h movement guidelines is significantly linked to various health indicators, including cardiometabolic biomarkers, fitness levels, mental health and overall quality of life in adults.[1,11] Early adulthood is recognized as a crucial phase for developing autonomy and

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https://doi.org/10.1016/j.jesf.2024.03.006
Received 27 October 2023; Received in revised form 10 March 2024; Accepted 16 March 2024
Available online 21 March 2024
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establishing long-term health behaviour patterns that persist into later stages of life.[6,12] Despite its critical importance, this life stage tends to be overlooked in health promotion initiatives,[13] highlighting the urgent need for greater scientific scrutiny and attention.

A novel concept that recently gained attention for fostering healthy and active lifestyle is physical literacy (PL),[14] which is defined as "motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life".[15] As a multidimensional construct, PL equips individuals with affective, cognitive, physical and behavioural attributes that could be integrated into the capability for a physically active lifestyle.[16,17] Empirical evidence have reported that physically literate individuals participate in higher levels of PA, spend more time in sports, and have lower levels of SB.[18,19] A positive relationship has also been found between PL and PA in children,[20] adolescents,[21] and university students in China.[22] A previous study, which embedded PL into an intervention design, emphasized the importance of PL in the 24-h movement guidelines for school-aged children in Hong Kong.[23] This comprehensive approach encompasses physical education, recess, and PA opportunities throughout the school day and before and after school, facilitating children in meeting the movement guideline within a 24-h period.[24] However, there is limited understanding of the associations between PL and meeting the 24-h movement guidelines, with insufficient supporting evidence.

Although positioned as a crucial for promoting PA participation, reducing SB, and acquiring adequate sleep within a 24-h period,[25] inadequate development of PL during the transition from childhood to early adulthood may contribute to more significant health issues among emerging adults.[6,7] For instance, the Asia-Pacific consensus statement on integrated 24-h activity guidelines especially emphasises enhancing physical performance, improving PL (movement skills) and reducing injury risk in children and adolescents.[26] However, the specific population of early adulthood (i.e., university students or college students) has been neglected. It is essential to investigate the associations between PL and adherence to 24-h movement guidelines within this cohort before advocating PL as a method for fostering a sustainable healthy lifestyle post-school required physical education requirements. PL, as a conceptual framework, influences various aspects of human functioning, highlighting the importance of understanding it relationship to 24-h movement behaviours. The holistic perspective considers the comprehensive nature of movement behaviours individuals engage in, rather than solely focusing on specific aspects, such as MVPA etc. To our knowledge, only one study has examined how children aged 8–12 years who meet PA and SB guidelines within the 24-h movement guidelines demonstrate higher levels of PL, particularly in terms of motivation, confidence, and physical competence.[18] There is a significant gap in studies exploring the associations between PL and adherence to 24-h movement guidelines (i.e., PA, SB, and sleep) among university students during early adulthood, as they transition out of school-required physical education. Without investigating and elucidating this association within the university-aged population, advocating for PL as an approach to enhance PA and promote a healthier lifestyle within this cohort may be premature.

Therefore, this cross-sectional study aims to investigate the association between levels of PL (i.e., confidence and physical competence, motivation, and interaction with the environment) and adherence to the 24-h movement guidelines among Chinese university students.

2. Methods

2.1. Participants and recruitment

Participants were recruited from two universities and two colleges situated in Gaoxin district, Chongqing, China. One class of freshmen and sophomores from each institution was randomly selected, resulting in a total of 8 classes of university/college (referred as university hereinafter) students. In total, 798 participants (390 male, 19.2 ± 1.2 years) were included. Inclusion criteria were limited to healthy students with no restrictions imposed in terms of sports participation. Data collection took place in November and December of 2020. Ethics approval was obtained by the Institution Review Board of the Ethics Advisory Committee at Chongqing University. In addition, the study was approved by the directors of the four selected schools and informed written consent was obtained from the participants prior to the enrolment.

2.2. Measures

Weight and height were measured to the nearest 0.1 kg and 0.1 cm, respectively. PL, PA, SB, and sleep were assessed via questionnaires. In addition, age and sex were self-reported, followed by the completion of the questionnaires. All measurements were administered at the class level during one of their twice-weekly physical education classes in the local university sports halls (lasting 90 min each). The questionnaires were printed and bound together into a three-page document. Two trained research assistants were available to address any questions raised by the participants while responding to the questionnaires.

2.2.1. Physical literacy

PL was evaluated via the simplified Chinese version of the Perceived Physical Literacy Instrument among Chinese university students.[27] It is an eight-item questionnaire (total score = 40), consisting of three domains: Confidence and Physical Competence (3 items, score = 15), Motivation (3 items, score = 15), and Interaction with the Environment (2 items, score = 10). Each item was rated based on a 5-point Likert-type scale, ranging from strongly disagree to strongly agree. The questionnaire was adapted and validated from the Perceived Physical Literacy Instrument, the traditional Chinese version developed in Hong Kong.[28]

2.2.2. Physical activity and sedentary behaviour

PA was subjectively assessed via a Chinese version of the International Physical Activity Questionnaire, short form (IPAQ-SF), which has been shown to be reliable and valid for adults.[29] The IPAQ-SF inquires the average time spent on light PA (LPA), moderate PA (MPA), and vigorous PA (VPA) daily, enabling the computation of cumulative time for LPA, MPA, and VPA over a week. Thereby, the weekly time for MVPA was determined by summing the durations of MPA and VPA. Daily SB time was obtained directly from the IPAQ-SF questionnaire.

2.2.3. Sleep

Participants' sleep duration and quality were assessed by a validated Chinese version of the Pittsburgh Sleep Quality Index (PSQI).[30,31] It is a self-reported questionnaire inquiring the sleep duration and quality over the recent month, consisting of 19 items and seven component scores (e.g., subjective sleep quality and sleep latency), with the outcome measure being the global PSQI score (ranging from 0 to 21). A total score ≥5 indicates impaired sleep quality. Sleep duration was calculated using the reported bedtimes and wake-up times, whereas sleep quality was evaluated using the PSQI instruction form.[30]

2.3. Data analysis

Descriptive statistics were reported as means and standard deviations. Body Mass Index (BMI) was calculated via dividing weight (in kilograms) by height (in metres) squared. MVPA (<150, ≥150 min/week), SB (≥8, <8 h/day), and sleep (<7 or >9, 7–9 h/day) were coded as 0 or 1, indicating not meeting or meeting with the 24-h movement guidelines for adults.[5] These codes were further categorised into four groups: 0 (not meeting any of the guidelines), 1 (meeting one guideline), 2 (meeting two guidelines) and 3 (meeting all the guidelines). The normal distribution of data was examined using the Shapiro-Wilk test, while the homogeneity of variances was assessed via Levene's test.

Independent sample t-tests were used to compare the differences in PL between males and females, and PL differences between meeting or not meeting the guidelines. Two-way ANOVA was conducted to determine any associations between the number of guidelines met (0, 1, 2, or 3) and levels of physical literacy (overall score and domain scores). Sex and guideline compliance interactions were considered initially. However, they were removed subsequently due to lack of significance. BMI and sex were included as covariates in the analysis. In the event of significant effects, follow-up post hot analyses, with Bonferroni adjustment where applicable, were performed as necessary. All the data analyses were performed in SPSS (version 28, IBM Corp., Armonk, NY, United States). Statistical significance was set at $p < 0.05$.

3. Results

Descriptive characteristics of the study are presented in Table 1. In total, 798 (390 males) university students participated in this cross-sectional survey, with males being significantly younger than females. No violation of normal distribution or homogeneity of variance were observed (all $p > 0.05$). There was no sex difference in terms of BMI. Regarding PA levels, no significant differences were found in LPA, MPA, and VPA between males and females. However, males accumulated significantly more MVPA per week (289.0 ± 333.0 min) than females (262.3 ± 328.6 min, $p = 0.03$). By contrast, females spent more time being sedentary (5.7 ± 3.2 h/day) compared to males (5.2 ± 3.1 h/day, $p = 0.03$). In addition, females slept slightly longer than males, with an average of 7.7 h per day compared to 7.5 h ($p = 0.02$) for females and males, respectively. However, there were no significant differences between sexes in terms of sleep quality. The average scores for PL were 30.7 for the overall score, 11.3 for the Confidence and Physical Competence domain, 12.1 for the Motivation domain, and 7.4 for the Interaction with the Environment domain. No significant sex differences were found in these PL scores.

The proportion of university students meeting PA, SB, and sleep guidelines was presented in Fig. 1. Among the participants, 36.5% (n = 291) met all three guidelines, while 4.1% (n = 33) met none of the guidelines. Most of the participants (n = 677, 85.0%) met the guideline for SB, followed by the guideline for sleep (n = 580, 72.8%) and PA (n = 427, 53.6%).

Fig. 2 illustrates the comparisons of overall PL scores and domain scores between participants who met and did not meet the 24-h movement guidelines. Participants (n = 427) who met the PA guideline, defined as participating in a minimum of 150 min of MVPA per week,

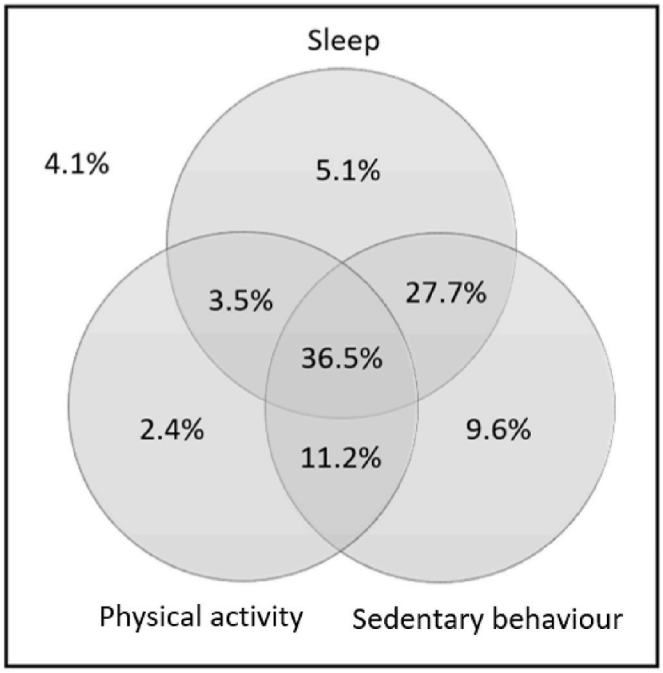

Fig. 1. Proportion (%) of participants meeting with the 24-h movement guideline(s).

showed significantly higher levels of PL overall and domain scores (all $p < 0.05$). Similarly, participants who met the SB guideline (less than 8 h of SB per day) were associated with significantly higher overall PL score and scores for Confidence and Physical Competence and Motivation domains ($p < 0.05$), but not for Interaction with the Environment domain ($p = 0.16$). By contrast, no significant PL difference was found for compliance with sleep guideline, except for those who did not meet with sleep guideline, demonstrating a higher score for the domain of Interaction with the Environment ($p = 0.003$).

Table 2 shows the differences between meeting different numbers of guidelines and overall PL and domain scores. The results demonstrate that, for both overall PL and the Confidence and Physical Competence domain, participants who met all the three guidelines had significantly higher PL scores compared to participants who met none, one, or two guidelines. Conversely, meeting none of the guidelines was associated

Table 1
Descriptive characteristics of participants' age, body mass index, physical activity, sedentary behaviour, sleep and physical literacy.

Variables	Males		Females		Overall		*p*
	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD	
Age	**390**	**18.9 ± 1.0**	**408**	**19.5 ± 1.3**	**798**	**19.2 ± 1.2**	**<0.01***
BMI	390	21.4 ± 4.5	408	20.9 ± 3.7	798	21.1 ± 4.1	0.18
Physical activity							
LPA-mins/week	390	602.0 ± 515.0	408	602.9 ± 597.1	798	602.5 ± 558.1	0.98
MPA-mins/week	390	160.6 ± 247.5	408	131.2 ± 181.6	798	145.6 ± 216.7	0.06
VPA-mins/week	390	128.4 ± 167.9	408	105.6 ± 242.5	798	116.8 ± 209.5	0.12
MVPA-mins/week	**390**	**289.0 ± 333.0**	**408**	**236.8 ± 322.6**	**798**	**262.3 ± 328.6**	**0.03***
Sedentary behaviour							
Sedentary-hours/day	**390**	**5.2 ± 3.1**	**408**	**5.7 ± 3.2**	**798**	**5.4 ± 3.2**	**0.03***
Sleep							
Sleep-hours/day	**390**	**7.5 ± 1.0**	**408**	**7.7 ± 1.1**	**798**	**7.6 ± 1.1**	**0.02***
Sleep quality	390	7.0 ± 3.1	408	7.2 ± 3.1	798	7.1 ± 3.1	0.36
Physical literacy							
Overall	390	30.6 ± 4.2	408	30.9 ± 4.0	798	30.7 ± 4.1	0.39
Confidence and Physical Competence	390	11.3 ± 2.2	408	11.4 ± 2.0	798	11.3 ± 2.1	0.70
Motivation	390	12.1 ± 1.9	408	12.1 ± 1.7	798	12.1 ± 1.8	0.90
Interaction with the Environment	390	7.4 ± 1.7	408	7.4 ± 1.6	798	7.4 ± 1.7	0.53

SD, standard deviation; BMI, body mass index; LPA, light physical activity; MPA, moderate physical activity; VPA, vigorous physical activity; MVPA, moderate-to-vigorous physical activity.

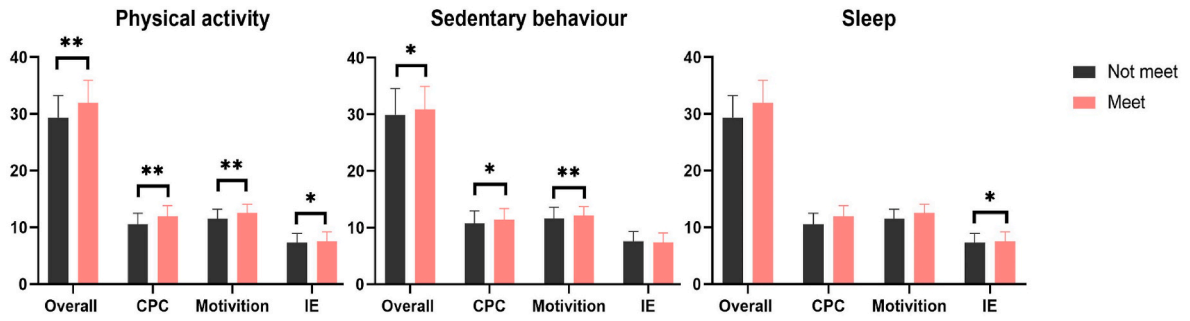

Fig. 2. Comparisons of overall physical literacy scores and domain scores between participants who met and did not meet the 24-h movement guidelines. CPC, Confidence and Physical Competence; IE, Interaction with the Environment. *, $p \leq 0.05$; **, $p \leq 0.01$.

Table 2
Differences between meeting different number of guidelines in terms of overall and domain physical literacy scores.

Number of guidelines met	0		1		2		3	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Overall physical literacy	33	27.58 (4.61)	137	30.23 (3.68)[a]	337	30.32 (4.18)[a]	291	31.93 (3.91)[a b c]
Confidence and Physical Competence	33	9.45 (2.00)	137	10.80 (1.86)[a]	337	11.11 (2.02)[a]	291	11.89 (1.92)[a b c]
Motivation	33	10.58 (2.51)	137	11.77 (1.46)[a]	337	11.93 (1.63)[a]	291	12.52 (1.49)[a b]
Interaction with the Environment	33	7.76 (1.75)	137	7.56 (1.51)	337	7.28 (1.77)	291	7.44 (1.62)

SD, standard deviation.
[a] significant difference with meeting none of guidelines.
[b] significant difference between meeting with all guidelines and meeting with one guideline.
[c] significant difference between meeting with all guidelines and meeting with two guidelines.

with significantly lower PL scores compared to participants who met one, two, or three guidelines (all $p < 0.05$). No significant findings were observed between participants who met one and two guidelines. Similar findings were also observed for the Motivation domain, except that participants who met three guidelines did not score significantly higher in PL than those who met two guidelines. No significant findings were observed for the Interaction with the Environment domain.

4. Discussion

This is the first study examining the associations between PL and adherence to the 24-h movement guidelines among university students. PL is positioned as the gateway to lifelong PA participation that it may potentially shape the trajectory of 24-h behaviours towards a healthier lifestyle.[25,32] However, previous studies have focused on the population of the children and adolescents, while little attention has been paid to PL development among young adults for promoting their health behaviours.[33,34] Higher education is usually viewed as the key stage for fostering PL through the life course, as it has been common for an individual to form habitual sport participation following the required physical education during school settings.[6,12] This study has emphasized the importance of research evidence towards PL among this population to establish an active lifestyle in the longer-term.[13]

The findings reveal that adhering to the 24-h movement guidelines, specifically for PA and SB rather than sleep, is associated with higher overall PL scores together with the sub-domains of PL scores among the Chinese university students. The 24-h day operates as a continuous cycle, and even a modest reduction in sedentary time, when replaced with PA, can yield significant health benefits.[11,35] Thus, our findings have the potential to improve PL for promoting the adherence to 24-h movement guidelines among the Chinese university students.

4.1. Adherence to 24-h movement guidelines in university students

The current study reveals that 63.5% of university students fail to meet all the 24-h movement guidelines, despite only 4.1% meeting none of the guidelines. On average, participants engaged in 262.3 min of MVPA per week, spent 5.4 h in SB, and slept for 7.6 h per day. However, although meeting the recommended sleep duration, participants reported experiencing poor sleep quality, evidenced by an average sleep quality score of 7.2, surpassing the threshold of ≤5 for good sleep quality.[30]

These findings are consistent with previous studies that investigated movement behaviours using IPAQ-SF in university students. For instance, Grimaldi-Puyana et al. (2020)[36] found that 71.3% of their 306 participants met the 150 min/week of MVPA, while 30.3% were categorised as poor sleepers. Similarly, Li et al. (2022) reported that 42.2 % (n = 990) of their participants had low levels of PA, with an average daily sedentary time of 5.3 h, and 48.6% (n = 1140) reported poor sleep quality.[10] In a study conducted in China by Ge et al. (2019), 47.2 % (n = 437) of university students engaged in a high level of MVPA, and 57.3% (n = 531) spent less than 8 h sitting daily.[1] Although participants reported an average sleep duration of 8.23 h per day in this study, the quality of sleep was not assessed. Contrary to the findings of the current study, several other studies have reported more than 9 h of SB on average among university students by means of objective[7,37,38] and self-reported[39] measurements. Additionally, a study by Tao et al. (2019) reported an extremely low level of MVPA per day (1.57 min) in university students, as objectively measured by ActiGraph GT9X.[38] Nevertheless, these studies also highlighted low sleep quality among university students.[37,38] Therefore, it seems the inconsistency in time allocation between MVPA and SB persists, with the choice of measurement tools likely contributing to the observed variations. Nonetheless, proactive measures should be taken to address sleep quality concerns among university students, even when they adhere to the recommended sleep duration.

4.2. Associations between physical literacy and meeting with 24-h movement guidelines

PL is a holistic concept that shares a reciprocal relationship with PA.[25,40] The development of PL holds the potential to encourage sound

health decision-making and promote long-term PA engagement.[34] Therefore, a physically literate population is more likely to comply with the 24-h movement guidelines. Yet, to the best of our knowledge, this is the first study to investigate the associations between the levels of PL and meeting the 24-h movement guidelines among the university students.

The present study demonstrates a significant association between overall PL scores as well as the domains of Confidence and Physical Competence and Motivation, and meeting the guidelines for PA and SB. Our findings, despite being based on university students, align with a study conducted by Belanger et al. (2018),[18] which involved 2956 participants aged 8–12 years. They found a positive correlation between meeting PA and SB guidelines and PL scores in domains related to Physical Competence and Motivation and Confidence, whereas the correlation was not significant for the domain of Knowledge and Understanding. Similarly, in another extensive cross-sectional study (n = 8307) involving 8 to 13-year-old children, Saunders et al. (2018) found a negative association between SB and the PL domains of Physical Competence and Motivation and Confidence.[41] However, it should be noted that in both studies, PL was assessed using a questionnaire developed by Longmuir et al.,[42] which is different from the PL assessment tool utilised in the present study.

The findings in the current study are further corroborated by empirical studies. A PL-based intervention demonstrated positive effects in mitigating the decline in PA among first-year university students, indicating a favourable link between PA and PL. It is worth noting, however, that this study did not thoroughly investigate the specific domains of PL contributing to the increased PA.[43] In a student-centred PL-orientated physical education programme delivered among university students in Hong Kong, the self-reported PA and PL domains of Motivation and Confidence in participating in physical education were improved simultaneously, highlighting the possible association between PA and PL.[44]

In the present study, no significant interactions were found between PL overall score and domain scores of Confidence and Physical Competence and Motivation, and meeting with the sleep guideline. It is conceivable that sleep issues are prevalent among university students, as documented in previous studies conducted in China,[9,10,37,38,45] which may have contributed to the nonsignificant findings. However, the reason behind the relationship between not meeting the sleep guideline and a higher PL domain score in Interaction with the Environment remains unclear. Our analysis indicated that meeting different number of guidelines did not appear to moderate the level of Interaction with the Environment. This finding aligns with a previous review, which highlighted that while Interaction with the Environment represents an important aspect of PL, most measurement tools, including questionnaires, has failed to capture these interactions effectively.[33]

Despite the unique findings of the present study, there are several limitations worth noting. Firstly, the participants were recruited from a convenient sampling method, specifically targeting first- and second-year university students. Given physical education is mandatory only during the initial first two years, there may be a potential bias in their reported physical activity levels when compared to the later stages of university life. Therefore, our results should be interpreted with caution. Secondly, the use of IPAQ-SF to evaluate PA and SB may result in underestimation of these variables.[46] Objective measures, such as accelerometers, would provide more accurate data in this regard. Additionally, the cross-sectional design in the present study limited our ability to determine the causal relationship between levels of PL and adherence to the movement guidelines. Future studies should consider longitudinal tracking or randomised controlled trials for further exploration. Furthermore, the IPAQ-SF did not enable the collection of screen time, which limited our ability to include the criterion of less than 3-h of recreational screen time in the SB guideline. Therefore, the number of participants who meet with the SB guideline in the current study may be underestimated.

5. Conclusion

In conclusion, this is the first study to explore the association between PL and adherence to the 24-h movement guidelines in university students. The findings have indicated that meeting the guidelines of PA and SB might be associated with a significantly higher overall PL score, as well as domain scores pertaining to Confidence and Physical Competence and Motivation. In addition, the present study revealed that a small proportion of university students met all the 24-h movement guidelines, albeit most participants met at least one of the guidelines. Furthermore, it is important to emphasise the urgent need for addressing sleep quality issues, even when meeting the recommended sleep duration among university students. Future investigations should aim to replicate these findings by incorporating accelerometer-based PA measurements and investigating the causal relationship between PL and adherence to the movement guidelines.

Ethical approval

All study procedures were approved by the Ethics Committee of Chongqing University Affiliated Swelling and Pain Hospital (Ethical code: CZLS2020148-A).

Funding

This study received no financial support.

Declaration of competing interest

The authors declare that they have no competing interests.

Acknowledgements

We would like to express our sincere appreciation to the university students and physical education teachers who participated in our study. Additionally, we wish to express our deep gratitude to the research assistants who played important roles in facilitating the data collection process.

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