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Combinations of physical activity, screen time and sleep, and their association with subjective wellbeing in children

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ABSTRACT

Background: Subjective wellbeing is an important indicator of health outcomes in children. 24-hour movement behaviours (i.e., physical activity, sedentary behaviour, sleep and their combination), a set of modifiable lifestyle behaviours, have been demonstrated to be associated with subjective wellbeing. Thus, the aim of this study was to investigate the relationship between the compliance of the 24-h movement guidelines and subjective wellbeing in a sample of Chinese children.

Methods: Cross-sectional data from primary and secondary school students in Anhui Province, China were used for the analysis. A total of 1098 study participants (mean age: 11.6 years, body mass index: 19.7 ± 2.9) were included, of which 51.5% were boys. Physical activity, screen time, sleep, and subjective wellbeing were measured using validated self-reported questionnaires. Multivariable logistic regression analysis was used to assess the relationships between the compliance of different combinations of 24-h movement guidelines and subjective wellbeing in participants.

Results: The compliance of (i.e., physical activity recommendations, screen time recommendations and sleep recommendations) 24-h movement guidelines was associated with better subjective wellbeing (OR: 2.09; 95CI%: 1.01–5.90) compared to the compliance of none of the guidelines. Furthermore, there was a dose–response relationship between the number of guidelines met ($3 > 2 > 1 > 0$) and improved subjective wellbeing ($p < 0.05$). Despite some exceptions, there was a significant relationship between the compliance of different combinations of the guidelines and better subjective wellbeing.

Conclusion: This study found that the compliance of 24-h movement guidelines was associated with greater subjective wellbeing in Chinese children.

1. Introduction

Globally there are more than 1.3 billion children, representing 16% of the whole world population [1,2]. Although childhood and adolescence are considered as critical stages of healthy development, 6.64 million children die every year due to transport, self-harm, interpersonal violence and other factors [3], resulting into more children experiencing a variety of diseases and injuries [4]. There has been a remarkable improvement in the overall health of children in recent decades, but the burden of nonfatal health losses has increased over the past decades [4]. Therefore, mental health problems are a major global health burden in children [5]. Substantial evidence illustrates that mental health problems during childhood and adolescence can affect their future physical and mental health [6–10]. Subjective wellbeing (SWB) reflects the positive aspects of mental health, and therefore SWB is an important indicator of mental health research [11].

Previous studies have demonstrated that higher levels of depression and anxiety are associated with lower SWB [12–14]. Moreover, higher SWB is associated with enhanced immune status, as well as reduced inflammation, musculoskeletal pain, and risk of mortality [15–17]. Therefore, SWB is an important element related to overall health. Previous research has illustrated that healthy movement behaviours are associated with SWB in children [18,19], and evidence on the association between movement behaviours and SWB in children is increasingly accumulating [20–22]. Movement behaviour compositions, physical activity (PA), sedentary behaviour (SB) and sleep, are independently associated with SWB. Previous evidence demonstrates the benefits of sufficient PA [23,24], limited SB [25,26], and adequate sleep [27] on

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physical and mental health. Emerging evidence indicates that all 24-h movement behaviours' compositions should be considered concurrently [28], because studying one movement behaviour in isolation would neglect the impact of other movement behaviours on health outcomes [29]. Consequently, Canada launched the first evidence-based 24-h movement guidelines in 2016 [30], which was subsequently followed by Australia, South Africa, and other countries [31]. In these guidelines, children are recommended to engage in at least 60 min of moderate to vigorous PA per day, limit recreational screen time (ST) to less than 2 h per day, and maintain a sleep duration of 9–11 h (5–13 years old) or 8–10 h (14–17 years old) [30]. However, previous studies have reported a low prevalence of the compliance of 24-h movement guidelines among children [32–34]. Meanwhile, due to the impact of the COVD-19 pandemic, the prevalence of compliance of the guidelines is now significantly lower than that before the outbreak [35–37].

Recently, there has been a growing interest in the relationship between the compliance of 24-h movement guidelines and SWB in children. A previous systematic review found that, in children, greater PA was associated with higher SWB, while more SB was associated with lower SWB [38]. Furthermore, a relationship between longer sleep duration and higher SWB was reported in a systematic review [27]. However, few studies have investigated the relationship between the compliance of 24-h movement guidelines and SWB in children since the COVID-19 pandemic. One study from Switzerland investigated the relationship between the compliance of 24-h movement guidelines and SWB in 2534 children aged 5–16 years, and found that participants who met the 24-h movement guidelines had higher levels of SWB [42]. Moreover, even meeting any one or a combination of any two recommendations of the guidelines was associated with higher SWB compared to meeting none of the 24-h movement guidelines [42,43]. Furthermore, there is also a lack of demographically representative studies investigating the relationship between the compliance of 24-h movement guidelines and SWB.

Consequently, the present study aimed to explore the association between the compliance of 24-h movement guidelines and SWB in a sample of Chinese children.

2. Methods

2.1. Study design and study participants

This cross-sectional survey was conducted in Anhui Province, China in 2021. This survey aimed to understand children's lifestyle behaviours and health, where study participants were recruited via a convenience sampling strategy. Participants completed an anonymous online questionnaire in the computer rooms in their schools. More than 2000 students were invited to take part in this study. Finally, 1098 school-aged students were included in this study after deleting invalid questionnaires. This survey study was approved by the West Anhui University and permission to conduct the study survey was obtained from the teachers and principals of each participating schools. All participants and their parents or guardians provided formal signed consent.

2.2. Measures

2.2.1. Dependent variables

SWB was measured using the Chinese version of the World Health Organization Five-Item Well-being Index (WHO-5) [37]. Participants reported the presence of positive feelings in the last 2 weeks on a six-point scale (5 = all the time, 0 = never). The possible total score of the WHO-5 ranges from 0 to 25, and a higher score indicates better subjective wellbeing. Psychometric properties of the Chinese version of WHO-5 have been validated among Chinese children [38, 39].

2.2.2. Independent variables

Sleep duration was measured using the Pittsburgh sleep quality index (PSQI), the question is that "How many hours did you actually sleep at night in the past month?" The Chinese version of the PSQI has been validated among Chinese children [44]. ST was measured using the relevant items from the Health Behavior in School-aged Children (HBSC) survey, including the time spent on various screen-based activities (i.e., watching TV, playing games with computers, chatting online with computers, etc.) in the past seven days. This questionnaire has been applied by many previous studies to investigate screen time in Chinese children [45,46], with acceptable reliability and validity. The average daily ST was calculated using the following formula: ([sum of ST in weekdays × 5] + [sum of weekend ST × 2])/7 [47]. MVPA was also measured using the relevant items from the HBSC survey, which asked about the number of days that included at least 60 min of MVPA in the past week. Items measuring ST and MVPA have been shown to have satisfactory reliability in Chinese children [48]. According to the Canadian 24-h movement guidelines [49], reporting 7 days with more than 60 min of MVPA was considered "meeting the PA guidelines"; no more than 2 h of ST per day was considered "meeting the ST guidelines"; sleep duration for 9–11 h and 8–10 h in children (5–12 years) and adolescents (13–17 years), respectively, was considered "meeting the sleep guidelines". Taken together, the combined cases of meeting the three guidelines can be determined as either the number of guidelines met (i.e., none, one, two, or all three) or specific combinations of 24-h movement guidelines met (i.e., none, MVPA only, ST only, sleep only, MVPA + ST, MVPA + sleep, ST + sleep, MVPA + ST + sleep).

2.2.3. Covariables

The following information was also gathered: sex (male/female), age, self-reported height (cm) and weight (kg), and family socioeconomic status (SES). Self-reported height and weight were also required for body mass index assessment according to China's norm-referenced data [50]. Family SES was measured using the adapted version of the MacArthur Scale of Subjective Social Status with a range from 0–10 [51].

2.3. Statistical analysis

Descriptive statistics were used to report sample characteristics. Generalised linear model analyses were used to examine the associations between SWB and meeting a general combination (the number of guidelines met, ranging from one to three) or specific combinations (none/sleep only/screen only/MVPA only/sleep + screen/sleep + MVPA/screen + MVPA/all) of 24-h movement guidelines after controlling for age, sex, body mass index and family socioeconomic status. A *p*-value lower than 0.05 was considered as statistically significant.

3. Results

3.1. Sample characteristics

Table 1 shows sample characteristics of participants in this study. In total, 1098 school-attending students were included for the final analysis. The percentages of boys and girls were 51.5% and 48.5%, respectively. The mean age of study participants was 11.6 ± 0.8 years, and the average BMI was 19.7 ± 2.9 kg/m^2. In terms of results for the compliance of the guidelines, the proportion of study participants meeting the sleep guidelines was 23.3%, and 8.7% of study participants met the screen guidelines. Approximately 59% of study participants met the MVPA guidelines. Regarding the 24-h movement guidelines, only 1.5% of study participants met the entire guidelines, and 30.0% of study participants met none of the guidelines. The proportion of participants who met the guidelines for sleep guidelines only, screen time guidelines only, and MVPA guidelines only was 9.3%, 39.8%, and 2.0%, respectively. In terms of the compliance of different combinations of the guidelines, the percentage of participants: meeting the sleep + screen time guidelines was 12.3%, meeting the sleep + MVPA guidelines in

Table 1
Sample characteristics of this study.

	n/mean	%/SD
Age (years)	11.6	0.8
Body mass index (kg/m^2)	19.7	2.9
Socioeconomic status	4.7	1.7
Sex		
Male	565	51.5
Female	533	48.5
Sleep guideline		
Not met	842	76.7
Met	256	23.3
Screen guideline		
Not met	455	41.4
Met	643	58.6
MVPA guideline		
Not met	1003	91.3
Met	95	8.7
Combinations of 24-h movement behaviour guidelines		
None	329	30.0
Sleep only	102	9.3
Screen time only	437	39.8
MVPA only	22	2.0
Sleep + screen time	135	12.3
Sleep + MVPA	2	0.2
Screen time + MVPA	54	4.9
All	17	1.5
Number of guidelines met		
0	329	30.0
1	561	51.1
2	191	17.4
3	17	1.5
Subjective wellbeing	16.9	5.0

n: number; SD: standard deviation; MVPA: moderate to vigorous physical activity.

combination was 0.2%, and meeting the screen time + MVPA guidelines in combination was 4.9%. In terms of the number of guidelines adhered to, only 1.5% and 17.4% of study participants met three and two guidelines, respectively, but 51.1% of study participants met only one guideline. The mean score of SWB was 16.9 with a standard deviation of 5.

3.2. Association between the compliance of 24-h movement guidelines and subjective wellbeing

The association of the number of movement behaviour guidelines met with SWB among Chinese children is presented in Table 2. After adjustment for a set of covariates, there was a significant association between the number of 24-h movement guidelines met by study participants and better SWB, suggesting the more guidelines met, the higher the scores of SWB ($p < 0.05$).

In Table 3, the association of the compliance of different combinations of 24-h movement guidelines and SWB among Chinese children is presented. After adjustment for covariates, the compliance of 24-h movement guidelines was associated with improved SWB (OR: 3.01; 95% CI: 1.49–5.42) compared to meeting none of the guidelines. The compliance of the screen time and sleep guidelines in combination was not significantly associated with better SWB. Furthermore, compared to meeting none of the three guidelines, compliance of sleep guidelines only, ST guidelines only, and PA guidelines only was positively associated with better SWB compared to meeting none of the 24-h movement guidelines.

Table 2
Associations of number of 24-h movement behaviour guidelines met with subjective wellbeing.

Number of 24-h movement behaviour guidelines met	Subjective Wellbeing		
	OR	95%CI	
One	**1.23**	**1.17**	**3.71**
Two	**1.58**	**1.04**	**4.55**
Three	**2.09**	**1.01**	**5.90**

OR: odds ratio; CI: confidence interval; Bold font represents p-value< 0.05.
Reference group: meeting none of the 24-h movement guidelines.
Models controlled for age, sex, body mass index and family socioeconomic status.

Table 3
Association of compliance with different combinations of 24-h movement behaviour guidelines and subjective wellbeing.

Compliance of different combinations of 24-h movement behaviour guidelines	Subjective Wellbeing		
	OR	95%CI	
Physical activity, screen time and sleep	**3.01**	**1.49**	**5.42**
Screen time and sleep duration	1.40	0.36	5.45
Physical activity and sleep	**4.38**	**3.77**	**7.52**
Physical activity and screen time	**3.02**	**2.16**	**5.27**
Sleep duration only	**2.72**	**1.89**	**5.22**
Screen time only	**3.03**	**1.47**	**6.24**
Physical activity only	**6.96**	**2.40**	**9.52**

OR: odds ratio; CI: confidence interval.
Reference group: meeting none of the 24-h movement guidelines.
Models controlled for age, sex, body mass index and family socioeconomic status.

4. Discussion

This study is the first cross-sectional study to investigate the relationship between SWB and the compliance of PA, ST and sleep guidelines in a sample of Chinese children. In the present study, the compliance of 24-h movement guidelines was associated with higher scores of SWB, and there appeared a dose–response relationship between the number of guidelines met and scores of SWB. The results of this study indicated that, in general, better movement behaviours patterns were significantly associated with enhanced SWB in children.

4.1. Comparison with previous studies

In terms of the compliance of 24-h movement behaviour guidelines, the prevalence of the compliance with screen time and sleep guidelines in insolation was similar to previous studies [52,53]. However, the prevalence of compliance of PA guidelines in this study was higher than that of other previous studies [52,53]. One possible explanation is that children tend to overestimate days for PA participations using self-reported questionnaires [54]. Several studies have investigated the relationships of PA, ST and sleep with SWB in children before and after the COVID-19 pandemic [27,38–41]. However, the majority of these studies have investigated these three movement behaviours independently rather than integrating them on a whole continuum. To the authors' best knowledge, only one study by Peralta et al. has investigated the relationship between the compliance of 24-h movement guidelines and SWB in children [42]. Peralta et al. examined changes in compliance with PA, ST and sleep guidelines in 2534 children during the COVID-19 pandemic in Switzerland, and explored the relationship between the compliance of 24-h movement guidelines and SWB [42].

Results of the study by Peralta et al. [42] showed that participants who met the three movement guidelines had greater SWB than those who did not meet any of the guidelines, and that there was a dose–response relationship between the number of guidelines achieved and better SWB, which supports the findings of the current study. Further exploring the relationship between different combinations of movement guidelines and SWB, we found that compared to the compliance of none of the integrated guidelines, compliance of all the three guidelines, compliance of the PA and sleep guidelines, compliance of the PA and ST guidelines, and compliance of the sleep guidelines only, ST guidelines only, and PA guidelines only was significantly associated with better

SWB. These results differ from the study by Peralta et al. [42]. One possible explanation is that different sample characteristics may lead to varying research findings [55]. Another potential reason is the difference in the measurement apporach used to assess SWB. The Cantril ladder was used in the Swiss study [42], whereas our study applied a different measure. Although both measurements are subjective measures for SWB, the Cartril ladder mainly focuses on life satisfaction [56], while the measure we used targets SWB. Andrews et al. suggest that SWB is composed of life satisfaction, positive affect, and negative affect [57]. Previous studies have shown that life satisfaction is one key component of SWB [58], while the global SWB is simply the sum of the three components [59]. Therefore, the differences in findings may be due to different components of SWB being measured. Nevertheless, our study provides evidence from a representative sample of children in China and demonstrates the relationships between SWB and PA, ST and sleep; thus, supporting the need for further investigation into lifestyle movement behaviours and SWB in this population.

4.2. Potential mechanisms

There are several mechanisms that may explain the current research findings in children. First, there is a bidirectional association between PA and SWB [60], wherein people with high SWB may be inclined to participate more in PA [61]. Second, participation in PA can improve physical and mental health, which can further increase life satisfaction and SWB. PA can improve self-rated physical health and physical function, which reduces the risk of cardiovascular disease, obesity and musculoskeletal disease, thus improving SWB [62–66]. Moreover, PA can improve SWB by improving body image, self-esteem, elf-efficacy, as well as lowering depression, anxiety, etc. [62,63,67–69]. Internal and external mechanisms may explain how PA improves SWB. The internal mechanisms include the sensations of pleasure, fluency, and climax that children experience through PA participation, which leads to more enjoyment for improved SWB [70], while the external mechanism is concerned with social communication with others through participation in PA, which subsequently leads to higher SWB [71]. Moreover, PA may activate mood-regulating neurotransmitters in the brain and accelerate the production of endorphins, thereby reducing feelings of pain [72,73]. Thus, PA could lead to higher SWB in children by reducing their perception of pain. Previous research has demonstrated that ST is an independent risk factor for both physical and mental health problems [14,74,75]. A potential mechanism is that excessive ST can lead to children's feeling of social isolation, and thus reporting lower SWB [76]. Prolonged ST is an independent risk factor for mental disorders such as depression and anxiety, and is associated with reduced life satisfaction, happiness and self-esteem [38]. Therefore, children who are exposed to longer ST may have poorer mental health, and are more likely to develop mental disorders; thus, further internalising lower SWB. Furthermore, social contact may also be inhibited based on the negative emotions, thus making children get more dependent on screens [77]. In children insufficient sleep time can lead to significant shifts in hypothalamic–pituitary–adrenal axis reactivity, resulting in increased pressure, and thus reducing SWB [78]. Moreover, emotional brain networks, rapid eye movement sleep-related mechanisms, emotional information processing, and the cognitive-energy model may be potential mechanisms by which sleep deprivation affects SWB [79]. There may also be a bidirectional relationship between sleep duration and SWB [79,80]. Taken together, it is reasonable to expect that 24-h movement behaviours can affect SWB in children.

4.3. Limitations and further recommendations

There are some limitations of this study. First, this study was cross-sectionally designed and was unable to identify causal relationships between 24-h movement behaviours and SWB. Future research should adopt a longitudinal design to better determine the direction of the associations. Second, SWB in this study was only assessed as a global score, which may not gain deep insights into movement behaviours and SWB. Therefore, future research needs to further investigate the relationships between the different components of SWB and 24-h movement behaviours to draw more specific practical implications. Third, although a self-reported questionnaire that used to measure 24-h movement behaviours in this study has good validity in children, it is unable to avoid the effects of recall and respondent bias. Future studies could use validated devices to objectively measure 24-h movement behaviours, taking into account the economic feasibility.

5. Conclusion

As the first study focusing on the relationship between compliance of 24-h movement guidelines and SWB in a sample of Chinese children, this study found that the compliance of PA, ST, sleep guidelines was associated with greater SWB.

Author contributions

JS summarized the findings and drafted the manuscript. JX and WS contributed to the formal analysis and editing of the manuscript. JS and WS developed the strategy of the manuscript and reviewed and edited the final manuscript. All authors have read and agreed to the published version of the manuscript.

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Declaration of competing interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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