frontiers | Frontiers in Pediatrics

TYPE Original Research
PUBLISHED 18 March 2024
DOI 10.3389/fped.2024.1337158

OPEN ACCESS

EDITED BY
Joemer Calderon Maravilla,
The University of Queensland, Australia

REVIEWED BY
Clare C. W. Yu,
Hong Kong Polytechnic University, Hong Kong SAR, China
Minghui Quan,
Shanghai University of Sport, China

*CORRESPONDENCE
Fang Li
✉ yllf2006@hynu.edu.cn
Pan Liu
✉ liupan8820@163.com

†These authors have contributed equally to this work and share first authorship

RECEIVED 12 November 2023
ACCEPTED 06 March 2024
PUBLISHED 18 March 2024

CITATION
Yin L, Li F, Liu P, Yin Z, Yang Z, Pi L and Gao Z (2024) Examining the relationship between meeting 24-hour movement behaviour guidelines and mental health in Chinese preschool children.
Front. Pediatr. 12:1337158.
doi: 10.3389/fped.2024.1337158

Examining the relationship between meeting 24-hour movement behaviour guidelines and mental health in Chinese preschool children

Long Yin[1†], Fang Li[2*†], Pan Liu[3*], Zhiqiang Yin[4], Zongyu Yang[5], Linchun Pi[6] and Zan Gao[7]

[1]College of Physical Education, Hunan Normal University, Changsha, China, [2]School of Physical Education, Hunan First Normal University, Changsha, China, [3]School of Physical Education, Hunan University of Technology, Zhuzhou, China, [4]English Course Group, Hengyang First High School, Hengyang, China, [5]School of Physical Education and Health Sciences, Guangxi University for Nationalities, Nanning, China, [6]School of Sports Science, Hengyang Normal University, Hengyang, China, [7]Department of Kinesiology, Recreation, and Sport Studies, The University of Tennessee, Knoxville, TN, United States

Background: Limited research has explored the relationship between adhering to 24-h Movement Behaviour guidelines and mental health in Chinese preschool children. The objectives of this study encompassed two primary goals: (1) to investigate the adherence of preschool children in China to the 24-h Movement Behaviour guidelines; and (2) to analyze the relationship between fulfilling various combinations of these guidelines and mental health, identifying the most advantageous combination.

Methods: Utilizing a convenience sampling approach, this study included 205 preschool children (117 boys and 88 girls, average age 4.8 ± 0.51 years) from five kindergartens in Hengyang, Hunan Province. The physical activity (PA) and sedentary behaviour of preschool children were objectively assessed using waist-worn accelerometers, while sleep duration and screen time were reported by the children's parents. To evaluate mental health, the parent version of the internationally validated Strength and Difficulties Questionnaire (SDQ) was employed, which measures externalizing problems, internalizing problems, and prosocial behaviour. Employing Mplus 8.0 for Structural Equation Modeling analysis, while controlling for demographic variables, the study explored the connection between preschool children's mental health and their adherence to the 24-h Movement Behaviour guidelines.

Results: Worryingly, merely 14.6% of preschoolers met the recommended guidelines for all three aspects (PA, sleep duration, and screen time). Positive correlations were identified between meeting PA guidelines and displaying prosocial behaviour ($\beta = 0.184$; $p < 0.05$), while screen time adherence exhibited a negative correlation with externalizing problems ($\beta = -0.207$; $p < 0.05$). Similarly, there was a negative association between sleep duration adherence and externalizing problems ($\beta = -0.191$; $p < 0.05$). Meeting all three recommended guidelines was notably linked to enhanced prosocial behaviour ($\beta = 0.464$; $p < 0.05$), while following the screen time and sleep duration guidelines was negatively associated with externalizing problems ($\beta = -0.246$; $p < 0.05$).

10.3389/fped.2024.1337158

Conclusion: This study underscores the limited adherence of Chinese preschoolers to the comprehensive 24-h Movement Behaviour guidelines. Noteworthy findings include the positive influence of PA on prosocial behaviour, alongside the significant roles that sleep duration and screen time play in mitigating externalizing problems within this age group. Alignment with the 24-h Movement Behaviour guidelines is associated with more favorable mental health indicators in preschoolers.

KEYWORDS

24-h Movement Behaviour, externalizing problems, internalizing problems, light-intensity physical activity, moderate-to-vigorous physical activity, prosocial behaviour, sedentary behaviour, screen time

1 Introduction

Mental health encompasses a condition of both physical and psychological well-being, facilitating efficient functioning that effectively manages external stressors and makes positive contributions to society (1). However, research indicates that an alarming 8%–10% of children under the age of 5 face mental health challenges, manifested in various forms. These challenges range from internalizing behaviors like anxiety and depression, to externalizing behaviors such as aggression, as well as neurodevelopmental disorders, notably attention-deficit/hyperactivity disorder (2). These concerns can arise early in life, potentially influencing the child's future state of well-being (3).

Appreciating the significance of mental well-being, the Chinese Ministry of Education has taken proactive measures through the implementation of the "Special Action Plan for Comprehensively Enhancing and Enhancing Students' Mental Health in the New Era (2023–2025)" (4), which harmonizes with the "Integrated Mental Health Action Plan 2013–2030" (5). This endeavor underscores the nationwide acknowledgment of mental health as a primary concern, thereby triggering heightened focus on the mental welfare of Chinese preschoolers. The emphasis lies in pinpointing factors that exert influence and formulating efficacious interventions. There exists a multitude of factors that exert an influence on mental well-being, and among these, moderate-to-vigorous physical activity (MVPA) stands out for its established benefits on the mental health, motor skills, and cognitive development of preschool children (6, 7). Furthermore, some research indicates that even light-intensity physical activity contributes positively to children's mental health (8). Beyond this, sufficient sleep duration has demonstrated the capacity to diminish the prevalence of anxiety and depression among children and adolescents (9, 10). Conversely, screen-based sedentary behaviour, encompassing activities such as television, tablet, and computer usage, has the potential to exert adverse effects on both physical and mental well-being (11, 12).

However, past research has primarily examined individual components such as physical activity (PA), sedentary behaviour, and sleep duration, scrutinizing their connections with specific facets of mental health, often overlooking the intricate interplays between these three behaviours (13, 14). Certain academics recognize the significance of holistically considering the cumulative impact of multiple behaviours, encompassing PA, sleep duration, and sedentary behaviour (15–17). Recent investigations have underscored that young children engage in sleep duration, sedentary behaviour, and PA throughout the entirety of the 24-h day, collectively termed as 24-h Movement Behaviour (18).

According to the guidelines provided by the World Health Organization, children aged 3–6 should engage in 3 h daily PA, including 60 min of MVPA. For children aged 3–4, daily screen time should be limited to 1 h, with a recommended sleep duration of 10 to 13 h per day. For children aged 5–6, daily screen time should be limited to 2 h, along with 9–11 h of sleep duration per day (19). Studies indicate that youngsters and teenagers who conform to these 24-h Movement Behaviour guidelines exhibit enhancements in emotional and psychosocial well-being (20), elevated cognitive performance (21), and a diminished occurrence of anxiety disorders and depression (22).

Furthermore, indications propose that apart from the favorable outcomes associated with adhering to the prescribed 24-h Movement Behaviour guidelines concerning the physical and mental health of young children, diverse amalgamations of strategies might produce differing impacts on well-being (23). Several studies have demonstrated that adherence to various configurations of the 24-h Movement Behaviour guidelines correlates with a reduced prevalence of depression and anxiety (22, 24, 25). Nonetheless, the literature does not uniformly ascertain which specific combinations of behaviors exhibit a stronger association with superior psychological functioning (22, 24, 25).Consequently, the identification of the most efficacious amalgamation of strategies for interventions aimed at mental health is of paramount importance (24).

Carson et al. identified specific combinations of PA + screen time and screen time + sleep duration linked to internalizing and externalizing problems among Canadian 3-year-olds (26). In a similar vein, Saunders et al. found that children and adolescents adhering to a low sedentary behaviour/high PA/sufficient sleep duration movement behaviour pattern displayed more favorable markers of obesity and cardiometabolism than those following a high sedentary behaviour/low PA/insufficient sleep duration pattern (23). However, it is worth noting that only a limited number of Chinese children and adolescents adhered to the

recommendations outlined in the 24-h Movement Behaviour guidelines (7, 27). Concurrently, research has indicated that among 11 countries spanning five major geographical regions of the world, Chinese children exhibit the least average daily participation in MVPA (28). Despite potential variations in cultural norms and policies across different geographical locations, a comparative analysis with Japanese children, who are also from the Asian region, reveals that Japanese children have higher levels of physical activity than their Chinese counterparts (29). Furthermore, the prevalence of various mental disorders among Chinese children and adolescents surpasses that of other countries (30). Consequently, investigating the potential link between physical activity behaviors and mental health within the Chinese population becomes particularly pressing. To our understanding, only a handful of studies have integrated the effects of adhering to the 24-h Movement Behaviour guidelines on mental health in samples of Chinese preschool children.

Thus, the primary aim of this study was to investigate the correlation between adherence to the 24-h Movement Behaviour guidelines and the mental well-being of Chinese preschool children. To be more specific, our primary goals are as follows: (1) to scrutinize the degree of conformity with the 24-h Movement Behaviour guidelines among preschoolers in China, and (2) to delve into the connection between adhering to diverse combinations of the 24-h Movement Behaviour guidelines and mental health outcomes, pinpointing which amalgamation holds greater potential for yielding substantial advantages. Gaining insights into the influence of these Behaviours on mental health will play a pivotal role in shaping the formulation of effective interventions, aimed at bolstering the overall wellness of Chinese preschool children.

2 Methods

2.1 Design and participants

For this study, a total of 306 preschool children aged 3–6 years were recruited from five kindergartens situated in Hengyang City, Hunan Province, China, utilizing a convenience sampling approach. All these preschoolers were attendees of Early Childhood Education and Care Services (ECECs) sanctioned by the Hengyang Education Bureau, and they were without any chronic health conditions. Before taking part in the study, the parents of these children were provided with information about the research, and their formal consent was acquired through the completion of a signed informed consent form. However, consent was not provided by 38 parents, and an additional 30 children were unable to participate in the testing within the specified time frame. This process resulted in gathering valid responses from 238 participants. However, due to incompleteness, 33 of these responses were later deemed unsuitable for analysis and thus excluded. The final sample comprised 205 preschool-aged children, with an average age of 4.8 years (SD = 0.51 years), including 117 boys and 88 girls (see Figure 1).

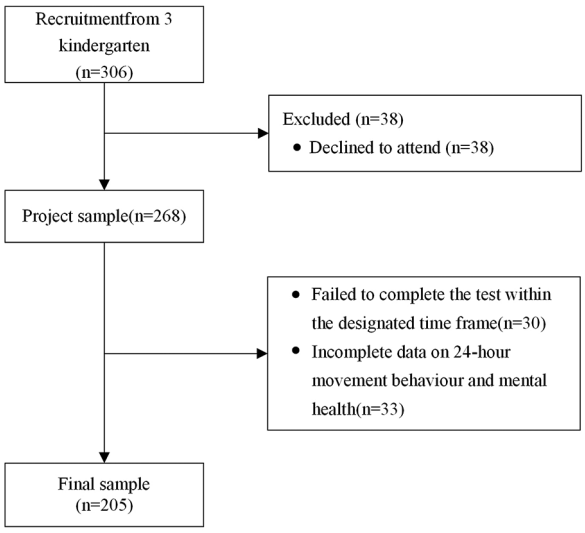

FIGURE 1
Process of recruitment and participant selection.

2.2 Measures

In the 2019 WHO guidelines and the 2020 physical activity and sedentary behavior guidelines, a structured daily regimen for children aged 3–6 is advocated (19, 31). For children aged 3–4 years, it is recommended to engage in at least 180 min of PA daily, including 60 min of moderate to vigorous physical activity (MVPA), limit screen time to no more than 1 h, and ensure a sleep duration of 10–13 h per day. For children aged 5–6 years, the guidelines suggest at least 60 min of MVPA daily, restricting screen time to no more than 2 h, and a sleep duration of 9–11 h per day. These guidelines provide a valuable framework for our research.

2.2.1 PA and sedentary behaviour

To obtain objective measurements of PA and sedentary behaviour among preschool children, a waist-worn accelerometer (Actigraph, model wGT3X-BT, USA), a validated instrument (32), was utilized. Kindergarten teachers and parents were provided instructions on the correct use of the accelerometer and were tasked with supervising the children while they wore it on a daily basis. The accelerometer was worn around the child's waist and right hip continuously for seven consecutive days, excluding times when the child was bathing, swimming, or sleeping. It recorded sedentary behaviour, light-intensity physical activity, moderate physical activity (MPA), and vigorous physical activity (VPA) in 15-second epochs specifically for preschoolers. Following the completion of the testing period, the accelerometers were initialized and the data were analyzed using ActiLife software (ActiGraph Corps., Pensacola, FL, USA; Version 6.13.3).

In this study, the PA intensity cut points proposed by Butte (2014) were applied, categorizing movement behaviour into sedentary behaviour at 239 counts/epoch, light-intensity physical activity in the range of 240–2,119 counts/epoch, MPA spanning

2,120–4,449 counts/epoch, and VPA at 4,450 counts/epoch (33). The total PA was computed by summing up light-intensity physical activity, MPA, and VPA, while MVPA was calculated by summing up MPA and VPA. To ensure valid accelerometer data, participants were required to wear the device for a minimum of 8 h per day on at least 3 valid days (consisting of two weekdays and one weekend day), in accordance with Choi et al.'s wear-time algorithm (34).

When considering sedentary behaviour in children, the primary focus is on screen time (35), which includes time spent using computers, TVs, and smartphones. To collect data on screen time, a questionnaire was provided to parents. The questionnaire contained the following question: "How much time does your child spend watching TV, using a computer, using a smartphone, or playing video games on weekday/weekends?" The average daily screen time was calculated using the formula: [(weekday screen time × 5 days] + [weekend screen time × 2 days)]/7 days.

2.2.2 Sleep duration

Data on sleep duration were collected using a validated questionnaire completed by the parents of the selected children (36). Data was collected independently for weekdays and weekends, encompassing both bedtime and wake-up time. The total sleep duration was calculated using the following formula: [(weekday night sleep duration × 5 days + weekend night sleep duration × 2 days)/7 days + (weekday daytime sleep duration × 5 days + weekend daytime sleep duration × 2 days)/7 days]. If any irregularities were observed in the collected data, the researchers promptly communicated with the parents to confirm the information.

2.2.3 Mental health

To evaluate the mental health of preschool children, this study employed the parent version of the Strength and Difficulties Questionnaire (SDQ), a widely recognized and validated instrument for assessing emotional issues, behavioral challenges, hyperactivity/inattention, peer relationship problems, and prosocial behavior in children aged 3–16 years (37, 38). The SDQ comprises 25 items divided across five subscales, each with five items. However, focusing on the study's specific aims, a three-factor model of the SDQ was adopted, concentrating on internalizing problems, externalizing problems, and prosocial behavior (39, 40). This model was specifically chosen for its applicability to a normal child population, where psychological health exhibits a normal variation range. It allows for an examination of how different scores within this normal range may still correlate with 24-h activity behaviors. The internalizing problems scale merges the emotional problems and peer relationship problems, while the externalizing problems scale encompasses the behavioral problems and hyperactivity/inattention subscales. Elevated scores in the internalizing and externalizing scales indicate increased psychological challenges, whereas higher scores in the prosocial behavior scale suggest enhanced psychosocial functioning. This adaptation was guided by prior literature endorsing the three-factor model's efficacy in general and low-risk child populations (39, 40), highlighting its relevance for our study's focus on exploring mental health trends within a preschool demographic, despite the absence of specific threshold values for these dimensions. This methodological decision aligns with the objective to broadly investigate mental health trends, emphasizing the importance of considering variations within the normal range and the potential for future research to further refine the SDQ's application in varied settings.

TABLE 1 Descriptive statistics of the sample.

	Mean	Standard deviation
Age (year)	4.89	0.74
MVPA (min/day)	48.5	14.54
PA (min/day)	257.93	40.91
SP (min/day)	636.79	56.24
ST (min/day)	106.61	63.08
BMI	15.63	1.636
Prosocial behaviour	6.73	1.72
INTER	6.43	2.50
EXTER	6.043	2.09

PA, physical activity; MVPA, moderate-to-vigorous physical activity; SP, sleep duration; ST, screen time; BMI, body mass index; INTER, internalizing problems; EXTER, externalizing problems.

2.2.4 Demographic characteristics

The study incorporated various demographic attributes as covariates, including the children's age, gender, height, weight, body mass index (BMI), and family socioeconomic status (SES), aligning with earlier research protocols (6, 9, 11). The data concerning these variables, except for family SES, were sourced from kindergarten teachers. Family socioeconomic status was gauged through a questionnaire that parents completed, comprising inquiries regarding parental occupation, education, and monthly household income (41). Utilizing principal component data analysis, the SES index was calculated, and the socioeconomic status was subsequently categorized into high, medium, or low tiers based on the standard deviation.

2.2.5 Statistical analysis

Participants were classified based on whether they met or did not meet the 24-h Movement Behaviour guidelines, as well as combinations thereof (e.g., meeting PA + screen time only, meeting PA + sleep duration only, meeting screen time + sleep duration only, and meeting all three guidelines). The sample data underwent descriptive statistical analyses, encompassing calculations of means, standard deviations (SD), and percentages.

For delving into the connection between preschool children's mental health and their adherence to the 24-h Movement Behaviour guidelines, Structural Equation Modeling analysis was conducted employing Mplus 8.0 (Muthén & Muthén, 2017) software. This analysis was adjusted for covariates including gender, age, BMI, and SES. The threshold for statistical significance in all analyses was set at $p < 0.05$.

3 Results

3.1 Descriptive analysis

Table 1 shows the descriptive statistics for preschool children's 24-h Movement Behaviour and mental health. Following the guidelines set forth by the World Health Organization (19), the preschoolers met the recommended total PA time but fell short of meeting the guidelines for MVPA. However, they did meet the guidelines for both sleep duration and screen time. Specifically, the average daily PA duration was 257 min, with MVPA accounting for 48.5 min. The children's daily sleep duration averaged 636.79 min, and their daily screen time amounted to 106.61 min.

Figure 2 displays a Venn diagram illustrating the proportion of preschoolers meeting the 24-h Movement Behaviour guidelines for various combinations of modalities. As depicted in the figure, the majority of preschoolers met the recommended guidelines for screen time (52.7%) and sleep duration (89.3%), while only 26.8% met the recommended guidelines for PA. Notably, 5.4% of preschoolers did not meet any of the recommended guidelines, and only 14.6% were able to meet all three recommended guidelines concurrently. Moreover, 2.4% met the combined PA and screen time recommendation, 8.8% met the combined PA and sleep duration recommendation, and 33.7% met the combined sleep duration and screen time recommendation.

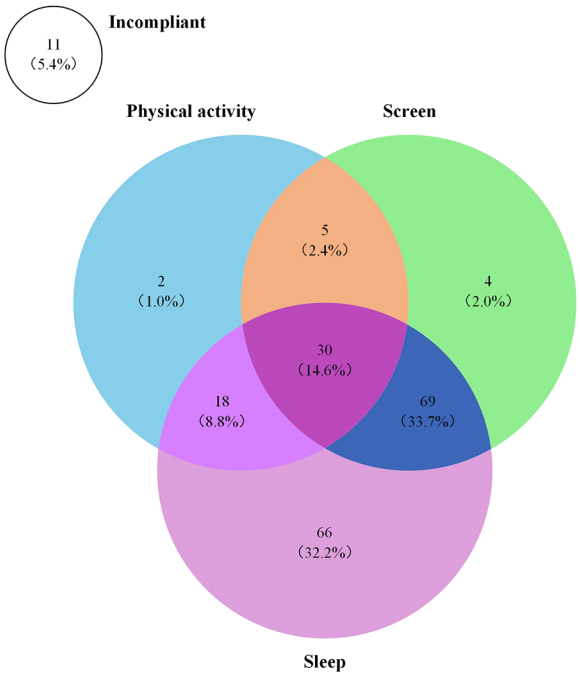

FIGURE 2
Proportion of participants meeting the 24-h Movement Behaviour guidelines in various combinations. The sum of each circle corresponds to the percentage of each recommendations met in the whole study sample (i.e., 26.8% physical activity, 89.3% sleep, 52.7% screen time, 5.4% non-compliance in the whole study sample).

TABLE 2 Relationship between meeting the 24-h Movement Behaviour guidelines and mental health.

	INTER		EXTER		PRO	
	β	*P*	*β*	*P*	*β*	*P*
PA	−0.124	0.144	0.069	0.401	**0.184**	**0.026**
ST	0.048	0.575	**−0.207**	**0.012**	0.089	0.286
SP	−0.129	0.129	**−0.191**	**0.018**	0.077	0.359
PA + ST + SP	−0.029	0.906	−0.331	0.16	**0.464**	**0.048**
PA + ST	0.193	0.365	0.271	0.185	−0.253	0.215
PA + SP	−0.237	0.084	0.119	0.371	0.036	0.788
ST + SP	−0.031	0.75	**−0.246**	**0.008**	0.075	0.427

PA, physical activity; SP, sleep duration; ST, screen time; INTER, internalizing problems; EXTER, externalizing problems, PRO, prosocial behaviour; Bold represents significant relationship.

3.2 Associations among meeting the guidelines and mental health

The initial model comprised 25 items, but the correlation index did not meet the standard (RMSEA = 0.07, CFI = 0.69, TLI = 0.66). To improve the model's fit, we eliminated items with low correlations (items 6, 11, 23, 7, 12, 22, 21, 25) and reconfigured the remaining 17 items into three dimensions: internalizing, externalizing, and prosocial behaviour. The adjusted second-round structure model demonstrated a significantly improved fit index (RMSEA = 0.04, CFI = 0.93, TLI = 0.91).

As seen from Table 2 and Figure 3, the relationship between adhering to individual guidelines for 24-h Movement Behaviour and mental health yielded compelling insights. Notably, children who met the PA guideline demonstrated a positive association with prosocial behaviour ($\beta = 0.184$; $p < 0.05$). Conversely, meeting the guidelines for screen time and sleep duration exhibited negative associations with externalizing problems ($\beta = -0.207$; $p < 0.05$ for screen time and $\beta = -0.191$; $p < 0.05$ for sleep duration).

In terms of the relationship between preschoolers adhering to the combined 24-h Movement Behaviour guidelines and their mental health, our data revealed significant outcomes. Preschoolers who met all three recommended guidelines displayed a positive association with prosocial behaviour ($\beta = 0.464$; $p < 0.05$). Moreover, meeting the guidelines for screen time and sleep duration demonstrated a negative association with externalizing problems ($\beta = -0.246$; $p < 0.05$). These findings provide valuable insights into the interplay between meeting multiple behavioural guidelines and its impact on the mental health of preschooler.

4 Discussion

4.1 Descriptive findings of compliance with the 24-h movement behaviour guidelines

The findings of this study unveil that a considerable majority of Chinese preschoolers adhere to the recommended guidelines for screen time at 52.7% and sleep duration at 89.3%, while only a modest portion meet the criteria for PA at 26.8%. Surprisingly, a mere 14.6% of preschoolers meet all three guidelines, with 5.4%

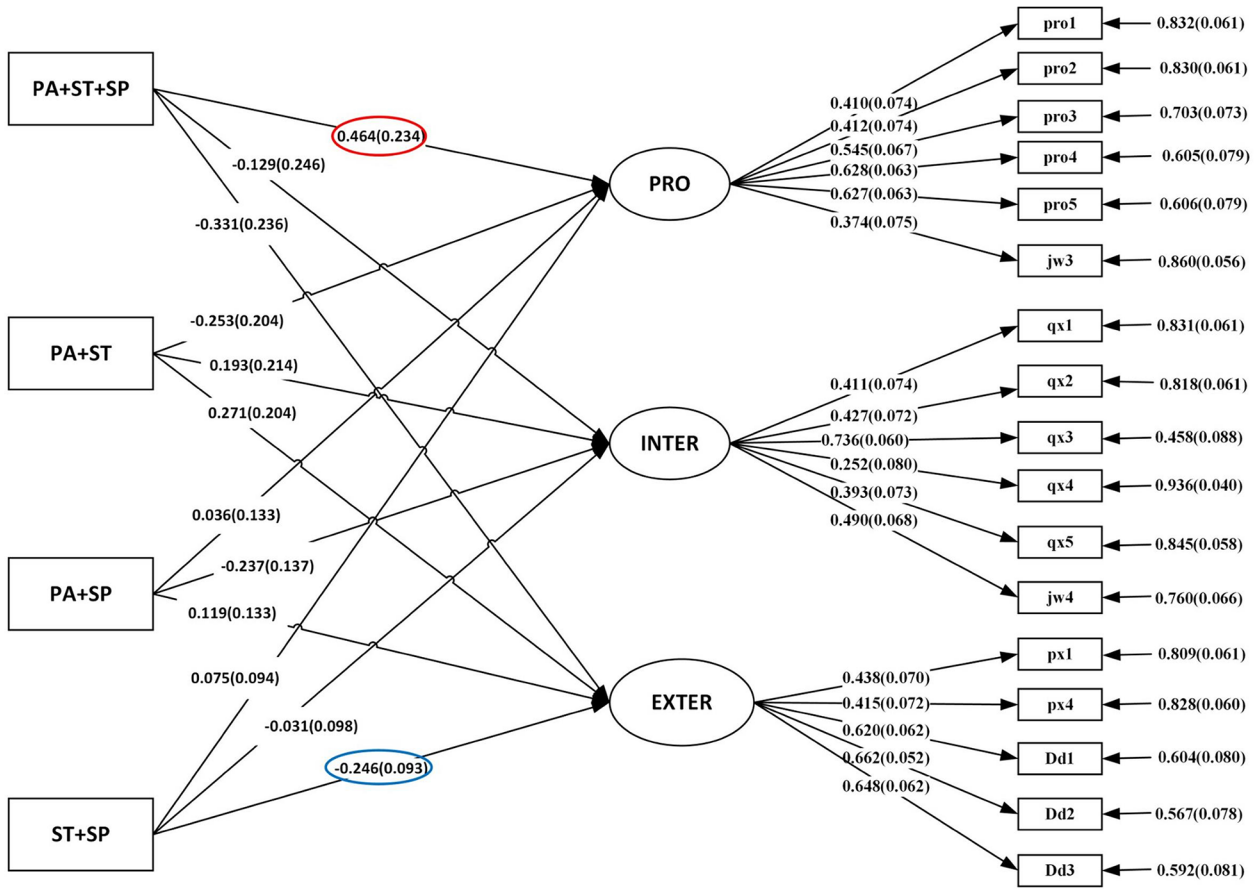

FIGURE 3
Structural modeling of the relationship between the combinations of met 24-h movement behaviour guidlines and mental health in preschoolers. PA, physical activity; SP, sleep; ST, sceen time; INTER, internalizing problems; EXTER, externalizing problems; PRO, prosocial behaviour. Colored with red line indicates significant positive relationship; Colored with blue line indicates significant negative relationship.

failing to meet any. These outcomes are consistent with earlier research that also yielded similar results (7, 42, 43). Noteworthy is the substantial proportion of preschoolers in our study who conform to the prescribed sleep duration (89.3%), which correlates with figures from Canada (83.9%) (42) and Australia (88.7%) (43). However, our study showcases a lower percentage in terms of meeting PA guidelines compared to Canada (61.8%) (42) and Australia (93.1%) (43), signifying a deficiency in aligning with the 24-h Movement Behaviour guidelines.

It is noteworthy to highlight that certain European studies have reported high levels of adherence to PA guidelines. For instance, Collings conducted a survey involving 333 preschool children in England, revealing that 95.4% of them meet the recommended 180 min of PA per day (44). Discrepancies such as these could potentially be attributed to variations in accelerometer utilization and cut-off points. The Australian study, similar to ours in accelerometer usage, employed a combination of two cut-off points to evaluate PA behaviour in children (45, 46), including a threshold of 420 counts per 15 s (c/15 s) for MVPA. In contrast, our study adopted Butte et al.'s recommendation, using 212° c/15 s as the MVPA cut-off point, which might lead to a lower detection rate of MVPA and consequently a decline in the overall PA detection rate (33). It's crucial to note, however, that Butte's cut-off point has been validated for application within preschool populations (33). Another potential factor contributing to the relatively low adherence to PA guidelines in China could be the strong emphasis on academic pursuits over PA, as a result of the prevailing concept of "intellectual priority" held by many parents.

4.2 Relationships between preschooler's mental health and compliance with the 24-h movement behaviour guidelines

The principal aim of this study was to explore the connection between adhering to the 24-h Movement Behaviour guidelines and the mental well-being of preschool children, while concurrently identifying the combinations that yield more substantial benefits. Our findings have illuminated several significant insights. Specifically, we observed that individual screen time or sleep duration behaviours exhibited a negative correlation with externalizing problems in children. Moreover, the combination of adhering to both screen time and sleep duration guidelines was also linked to a reduction in externalizing problems. These

findings suggest that adhering to the recommended sleep duration can potentially mitigate the occurrence of externalizing issues, encompassing hyperactivity and inattention. Furthermore, simultaneously adhering to both screen time and sleep duration guidelines seemed to confer a similar positive effect in diminishing externalizing problems. Although no statistically significant association emerged between PA and externalizing problems, a positive connection was discerned between PA and prosocial behaviour in children. Notably, meeting the 24-h Movement Behaviour guidelines in conjunction with adhering to the recommended screen time and sleep duration was positively correlated with prosocial behaviour among children. Given that prosocial behaviour is a positive facet (47), these findings underscore the benefits of adhering to PA recommendations for children's mental health. Moreover, the concurrent compliance with PA, screen time, and sleep duration recommendations was associated with improved mental health outcomes.

Primarily, our study has yielded evidence that insufficient sleep duration is associated with a heightened occurrence of externalizing behaviours, which include infractions and aggressive behaviours. This finding aligns seamlessly with outcomes reported in earlier research studies (48–50). The significance of adequate and high-quality sleep, recognized for its close correlation with both physical and mental health, cannot be underestimated (9). The impact of inadequate sleep extends to the brain's capacity to regulate and express emotions, thereby impairing the development of executive functions and giving rise to heightened irritability, anger, and impulsiveness (51, 52). Furthermore, inadequate sleep brings about daytime sleepiness and fatigue, curtailing the time available for PA and ultimately casting an adverse impact on both physical and mental well-being (53). Moreover, the proliferation of portable electronic devices has played a pivotal role in the upsurge of screen time among children. The ease of access to these devices has enabled children to bring them into their bedrooms, leading to delayed sleep initiation and reduced sleep duration. Consequently, this dynamic exerts an influence on both physical and mental health (54). To underscore this, a study encompassing 9 to 10-year-old children unveiled that increased screen time was linked to a heightened prevalence of externalizing behaviours (49).

Moreover, our study unveiled a significant and inverse correlation between meeting the combined screen time and sleep duration recommendation (screen time + sleep duration) and externalizing problems among preschoolers. This finding underscores that adhering to the screen time + sleep duration recommendation proves to be notably effective in mitigating externalizing problems. Notably, this outcome resonates with prior research findings (26, 50, 55), even though these previous studies focused on participants aged 9–12 years (50, 55). It is worth considering that emotional and behavioural challenges can manifest differently across various age groups (56), thereby accentuating the importance of delving into the mental health of children spanning different age brackets. To our knowledge, only a single study conducted in Canada has examined the relationship between meeting screen time and sleep duration recommendations and externalizing problems in younger children (3 years old) (26). Adding to the complexity are policy and cultural distinctions between Western nations and China. A cross-sectional investigation delving into the adherence to 24-h Movement Behaviour guidelines and their impact on the mental health of Chinese preschoolers can potentially establish a more comprehensive theoretical foundation within the realm of health promotion. In addition, our study brought to light a noteworthy positive connection between PA and preschool children's prosocial behaviour. This observation underscores that adhering to PA recommendations leads to an elevation in prosocial behaviour. Prosocial behaviour is an essential facet of social interaction, contributing to the establishment and sustenance of positive interpersonal relationships while fostering social unity (57). Prior research has validated that active engagement in PA tends to foster improved prosocial behaviour and concurrently diminish social interaction difficulties (47, 58). PA not only affords opportunities for interaction with peers but also cultivates essential social skills and bolsters problem-solving aptitudes, culminating in the advancement of prosocial behaviour (59). This finding consequently supports the reasoning for Physical Education educators to place emphasis on teamwork and problem-solving competencies within their instructional framework.

Furthermore, our study elucidated that meeting the joint recommendations for PA, screen time, and sleep duration concurrently correlated with enhanced prosocial behaviour in comparison to not meeting any of these recommendations. Numerous research endeavors have consistently highlighted that fulfilling all three guidelines not only leads to improvements in anxiety, depression, and life satisfaction but also augments prosocial behaviour (20, 22, 24). Children adhering to two or more of these recommendations have also demonstrated heightened social functionality across domains like externalizing problems, internalizing problems, and prosocial behaviour, coupled with lower stress levels (48). Hence, the logical inference emerges that the children in our study who fulfilled the combined PA + screen time + sleep duration recommendation exhibited superior prosocial behaviour. Nevertheless, it's noteworthy that merely 14.6% of children in our study concurrently fulfilled all three behavioural recommendations, while the majority met only one or two of them. It is plausible that this limited sample size could potentially impact the analysis of the relationship between fulfilling all three behavioural recommendations and mental health outcomes. Nonetheless, two longitudinal investigations have underscored that compliance with comprehensive guidelines doesn't necessarily correspond to improved psychosocial well-being over the course of one year (60) to three years (61). In light of this, it is prudent for future research endeavors to extend their scope beyond examining horizontal associations, and instead, allocate due emphasis on longitudinal interventions as well.

4.3 Study strengths and limitations

This study serves as a pioneering exploration of the connection between 24-h Movement Behaviour and mental health in Chinese preschool children, with a distinctive emphasis on delineating the most advantageous combinations of behaviours that significantly

contribute to children's mental well-being. The research boasts notable strengths, including the objective assessment of children's PA through accelerometers and the implementation of advanced statistical analysis techniques to interpret the amassed data. Nonetheless, it is imperative to acknowledge several limitations inherent to this study that merit thoughtful deliberation. To commence, it's essential to acknowledge that the evaluation of children's sleep duration, screen time, and mental health was reliant on questionnaires completed by parents, potentially introducing measurement biases. Acknowledging the potential discomfort associated with wearing an accelerometer on the right hip during sleep (62), a questionnaire was employed for sleep duration assessment, although it failed to encompass the measurement of sleep efficiency. Subsequent investigations should contemplate the incorporation of objective tools for appraising sleep in preschool children, thereby augmenting measurement precision. Moreover, this study's emphasis on sedentary behaviour primarily via screen time could inadvertently overshadow the impact of non-screen sedentary behaviour in children's everyday routines (11). To gain a more comprehensive insight into its potential sway on mental health outcomes, a broader analysis of sedentary behaviour patterns becomes imperative. Furthermore, the cross-sectional framework adopted in this study precludes the determination of causal relationships between movement behaviours and mental health outcomes. To establish causality, forthcoming research could embrace longitudinal designs, facilitating the tracking of changes over time. Lastly, the study's confined geographical range, conducted exclusively in a substantial city in south-central China, might restrict the generalizability of its findings to other locales or population groups. To establish a more extensive relevance, future investigations should contemplate the inclusion of diverse samples from various regions. Despite these acknowledged limitations, the current study constitutes a notable advancement in unraveling the intricate interplay between 24-h Movement Behaviour and mental health within the context of Chinese preschool children. The incorporation of accelerometers and meticulous statistical analyses not only bolsters the credibility of the findings but also accentuates the significance of the research. Undertaking proactive measures to address the outlined limitations in subsequent research endeavors holds the potential to amplify the field's comprehension of the intricate nexus between movement behaviours and mental well-being in this particular age cohort.

5 Conclusion

This study emphasizes the critical gap in adherence to the 24-h Movement Behaviour guidelines among Chinese preschoolers, with only 14.6% meeting the comprehensive guidelines for PA, sleep duration, and screen time. The findings highlight the positive impact of PA on fostering prosocial behaviour and the significant role that adherence to sleep duration and screen time guidelines plays in mitigating externalizing problems among this age group. These results underscore the importance of a holistic approach to Movement Behaviour guidelines to improve mental health outcomes in preschool children.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Hengyang Normal University Institutional Review Board (Study Number: 2021003). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

LY: Conceptualization, Writing – original draft. FL: Formal Analysis, Funding acquisition, Writing – review & editing. PL: Data curation, Formal Analysis, Investigation, Writing – review & editing. ZY: Investigation, Supervision, Writing – review & editing. ZY: Data curation, Investigation, Methodology, Writing – review & editing. LP: Data curation, Investigation, Methodology, Writing – review & editing. ZG: Supervision, Visualization, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article.

This study was funded by the Project of the Provincial education department of Hunan (No. 22B0721), the Youth Project of the Ministry of Education Humanities and Social Sciences Research in China (No. 21YJC890013), the Philosophy and Social Science Foundation of Hunan (No. 21YBA166).

Conflict of 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.

Publisher's note

References

1. World Health Organization. Mental Health. (2022). Available online at: https://www.who.int/news-room/facts-in-pictures/detail/mental-health (accessed July 8, 2022).

2. Gleason MM, Goldson E, Yogman MW, Lieser D, DelConte B, Donoghue E, et al. Addressing early childhood emotional and behavioral problems. *Pediatrics*. (2016) 138 (6):e20163025. doi: 10.1542/peds.2016-3025

3. Taylor RW, Haszard JJ, Healey D, Meredith-Jones KA, Taylor BJ, Galland BC. Adherence to 24-h movement behavior guidelines and psychosocial functioning in young children: a longitudinal analysis. *Int J Behav Nutr Phys Act*. (2021) 18(1):110. doi: 10.1186/s12966-021-01185-w

4. Ministry of Education of the People's Republic of China. Special Action Plan to Comprehensively Strengthen and Improve Student Mental Health in the New Era (2023–2025). (2023). Available online at: http://www.moe.gov.cn/srcsite/A17/moe_943/moe_946/202305/t20230511_1059219.html (accessed April 27, 2023).

5. World Health Organization. Comprehensive Mental Health Action Plan 2013–2030. (2021). Available online at: https://www.who.int/publications/i/item/9789240031029 (accessed September 21, 2021).

6. Carson V, Lee EY, Hewitt L, Jennings C, Hunter S, Kuzik N, et al. Systematic review of the relationships between physical activity and health indicators in the early years (0–4 years). *BMC Public Health*. (2017) 17(Suppl 5):854. doi: 10.1186/s12889-017-4860-0

7. Li F, Yin L, Sun M, Gao Z. Examining relationships among Chinese preschool children's meeting 24-hour movement guidelines and fundamental movement skills. *J Clin Med*. (2022) 11(19):5623. doi: 10.3390/jcm11195623

8. Poitras VJ, Gray CE, Borghese MM, Carson V, Chaput J-P, Janssen I, et al. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Appl Physiol Nutr Metab*. (2016) 41(6 Suppl 3):S197–239. doi: 10.1139/apnm-2015-0663

9. Chaput JP, Gray CE, Poitras VJ, Carson V, Gruber R, Birken CS, et al. Systematic review of the relationships between sleep duration and health indicators in the early years (0–4 years). *BMC Public Health*. (2017) 17(Suppl 5):855. doi: 10.1186/s12889-017-4850-2

10. Cousins JC, Whalen DJ, Dahl RE, Forbes EE, Olino TM, Ryan ND, et al. The bidirectional association between daytime affect and nighttime sleep in youth with anxiety and depression. *J Pediatr Psychol*. (2011) 36(9):969–79. doi: 10.1093/jpepsy/jsr036

11. Poitras VJ, Gray CE, Janssen X, Aubert S, Carson V, Faulkner G, et al. Systematic review of the relationships between sedentary behaviour and health indicators in the early years (0–4 years). *BMC Public Health*. (2017) 17(Suppl 5):868. doi: 10.1186/s12889-017-4849-8

12. Li C, Cheng G, Sha T, Cheng W, Yan Y. The relationships between screen use and health indicators among infants, toddlers, and preschoolers: a meta-analysis and systematic review. *Int J Environ Res Public Health*. (2020) 17(19):1–20. doi: 10.3390/ijerph17197324

13. Sund AM, Larsson B, Wichstrom L. Role of physical and sedentary activities in the development of depressive symptoms in early adolescence. *Soc Psychiatry Psychiatr Epidemiol*. (2011) 46(5):431–41. doi: 10.1007/s00127-010-0208-0

14. Belair MA, Kohen DE, Kingsbury M, Colman I. Relationship between leisure time physical activity, sedentary behaviour and symptoms of depression and anxiety: evidence from a population-based sample of Canadian adolescents. *BMJ Open*. (2018) 8(10):e021119. doi: 10.1136/bmjopen-2017-021119

15. Tremblay MS, Esliger DW, Tremblay A, Colley R. Incidental movement, lifestyle-embedded activity and sleep: new frontiers in physical activity assessment. *Can J Public Health*. (2007) 98 Suppl 2(S2E):S208–17. doi: 10.1139/h07-130

16. Chaput JP, Carson V, Gray CE, Tremblay MS. Importance of all movement behaviors in a 24 h period for overall health. *Int J Environ Res Public Health*. (2014) 11(12):12575–81. doi: 10.3390/ijerph111212575

17. Prochaska JJ, Spring B, Nigg CR. Multiple health behavior change research: an introduction and overview. *Prev Med*. (2008) 46(3):181–8. doi: 10.1016/j.ypmed.2008.02.001

18. Tremblay MS, Carson V, Chaput JP, Connor Gorber S, Dinh T, Duggan M, et al. Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behaviour, and sleep. *Appl Physiol Nutr Metab*. (2016) 41(6 Suppl 3):S311–27. doi: 10.1139/apnm-2016-0151

19. World Health Organization. Guidelines on Physical Activity, Sedentary Behaviour and Sleep for Children Under 5 Years of Age. (2019). Available online at: https://www.who.int/publications/i/item/9789241550536 (accessed April 2, 2019).

20. Janssen I, Roberts KC, Thompson W. Is adherence to the Canadian 24-hour movement behaviour guidelines for children and youth associated with improved indicators of physical, mental, and social health? *Appl Physiol Nutr Metab*. (2017) 42(7):725–31. doi: 10.1139/apnm-2016-0681

21. Walsh JJ, Barnes JD, Cameron JD, Goldfield GS, Chaput JP, Gunnell KE, et al. Associations between 24 h movement behaviours and global cognition in US children: a cross-sectional observational study. *Lancet Child Adolesc Health*. (2018) 2 (11):783–91. doi: 10.1016/S2352-4642(18)30278-5

22. Zhu X, Haegele JA, Healy S. Movement and mental health: behavioral correlates of anxiety and depression among children of 6–17 years old in the U.S. *Ment Health Phys Act*. (2019) 16:60–5. doi: 10.1016/j.mhpa.2019.04.002

23. Saunders TJ, Gray CE, Poitras VJ, Chaput JP, Janssen I, Katzmarzyk PT, et al. Combinations of physical activity, sedentary behaviour and sleep: relationships with health indicators in school-aged children and youth. *Appl Physiol Nutr Metab*. (2016) 41(6 Suppl 3):S283–93. doi: 10.1139/apnm-2015-0626

24. Lu S, Cheval B, Yu Q, Hossain MM, Chen ST, Taylor A, et al. Associations of 24-hour movement behavior with depressive symptoms and anxiety in children: cross-sectional findings from a Chinese sample. *Healthcare (Basel)*. (2021) 9(11):11. doi: 10.3390/healthcare9111532

25. Sampasa-Kanyinga H, Chaput J-P, Goldfield GS, Janssen I, Wang J, Hamilton HA, et al. The Canadian 24-hour movement guidelines and psychological distress among adolescents: les directives Canadiennes en matière de mouvement sur 24 heures et la détresse psychologique chez les adolescents. *Can J Psychiatry*. (2020) 66 (7):624–33. doi: 10.1177/0706743720970863

26. Carson V, Ezeugwu VE, Tamana SK, Chikuma J, Lefebvre DL, Azad MB, et al. Associations between meeting the Canadian 24-hour movement guidelines for the early years and behavioral and emotional problems among 3-year-olds. *J Sci Med Sport*. (2019) 22(7):797–802. doi: 10.1016/j.jsams.2019.01.003

27. Chen ST, Liu Y, Tremblay MS, Hong JT, Tang Y, Cao ZB, et al. Meeting 24-h movement guidelines: prevalence, correlates, and the relationships with overweight and obesity among Chinese children and adolescents. *J Sport Health Sci*. (2021) 10 (3):349–59. doi: 10.1016/j.jshs.2020.07.002

28. Sampasa-Kanyinga H, Standage M, Tremblay MS, Katzmarzyk PT, Hu G, Kuriyan R, et al. Associations between meeting combinations of 24-h movement guidelines and health-related quality of life in children from 12 countries. *Public Health*. (2017) 153:16–24. doi: 10.1016/j.puhe.2017.07.010

29. Yang G, Zhang M, Ujihara H, Xu J, Zhou S. A comparative study on visual health and physical activity of Chinese and Japanese children aged 6–12 years. *Am J Health Behav*. (2022) 46(5):567–75. doi: 10.5993/AJHB.46.5.7

30. Li F, Cui Y, Li Y, Guo L, Ke X, Liu J, et al. Prevalence of mental disorders in school children and adolescents in China: diagnostic data from detailed clinical assessments of 17,524 individuals. *J Child Psychol Psychiatry*. (2022) 63(1):34–46. doi: 10.1111/jcpp.13445

31. World Health Organization. WHO Guidelines on Physical Activity and Sedentary Behaviour. (2020). Available online at: https://www.who.int/publications/i/item/9789240015128 (accessed November 25, 2020).

32. Barnett LM, van Beurden E, Morgan PJ, Brooks LO, Beard JR. Gender differences in motor skill proficiency from childhood to adolescence: a longitudinal study. *Res Q Exerc Sport*. (2010) 81(2):162–70. doi: 10.1080/02701367.2010.10599663

33. Butte NF, Wong WW, Lee JS, Adolph AL, Puyau MR, Zakeri IF. Prediction of energy expenditure and physical activity in preschoolers. *Med Sci Sports Exerc*. (2014) 46(6):1216–26. doi: 10.1249/MSS.0000000000000209

34. Choi L, Liu Z, Matthews CE, Buchowski MS. Validation of accelerometer wear and nonwear time classification algorithm. *Med Sci Sports Exerc*. (2011) 43(2):357–64. doi: 10.1249/MSS.0b013e3181ed61a3

35. Webster EK, Martin CK, Staiano AE. Fundamental motor skills, screen-time, and physical activity in preschoolers. *J Sport Health Sci*. (2019) 8(2):114–21. doi: 10.1016/j.jshs.2018.11.006

36. Liu Z, Wang G, Geng L, Luo J, Li N, Owens J. Sleep patterns, sleep disturbances, and associated factors among Chinese urban kindergarten children. *Behav Sleep Med*. (2016) 14(1):100–17. doi: 10.1080/15402002.2014.963581

37. Goodman R. Psychometric properties of the strengths and difficulties questionnaire. *J Am Acad Child Adolesc Psychiatry*. (2001) 40(11):1337–45. doi: 10.1097/00004583-200111000-00015

38. Du Y, Kou J, Coghill D. The validity, reliability and normative scores of the parent, teacher and self report versions of the strengths and difficulties questionnaire in China. *Child Adolesc Psychiatry Ment Health*. (2008) 2(1):8. doi: 10.1186/1753-2000-2-8

39. Aaro LE, Davids EL, Mathews C, Wubs AG, Smith ORF, de Vries PJ. Internalizing problems, externalizing problems, and prosocial behavior—three dimensions of the strengths and difficulties questionnaire (SDQ): a study among South African adolescents. *Scand J Psychol*. (2022) 63(4):415–25. doi: 10.1111/sjop.12815

40. Goodman A, Lamping DL, Ploubidis GB. When to use broader internalising and externalising subscales instead of the hypothesised five subscales on the strengths and difficulties questionnaire (SDQ): data from British parents, teachers and children. *J Abnorm Child Psychol*. (2010) 38(8):1179–91. doi: 10.1007/s10802-010-9434-x

41. Zhang N, Wang Y, Xu Z-x. A study of the influence of family socioeconomic status onstudents' Guardians' satisfaction of education. *J Educ Stud*. (2013) 9:81–91. doi: 10.14082/j.cnki.1673-1298.2013.03.008

42. Chaput JP, Colley RC, Aubert S, Carson V, Janssen I, Roberts KC, et al. Proportion of preschool-aged children meeting the Canadian 24-hour movement

guidelines and associations with adiposity: results from the Canadian health measures survey. *BMC Public Health*. (2017) 17(Suppl 5):829. doi: 10.1186/s12889-017-4854-y

43. Cliff DP, McNeill J, Vella SA, Howard SJ, Santos R, Batterham M, et al. Adherence to 24-hour movement guidelines for the early years and associations with social-cognitive development among Australian preschool children. *BMC Public Health*. (2017) 17(Suppl 5):857. doi: 10.1186/s12889-017-4858-7

44. Collings PJ, Brage S, Bingham DD, Costa S, West J, McEachan RRC, et al. Physical activity, sedentary time, and fatness in a biethnic sample of young children. *Med Sci Sports Exerc*. (2017) 49(5):930–8. doi: 10.1249/MSS.0000000000001180

45. Evenson KR, Catellier DJ, Gill K, Ondrak KS, McMurray RG. Calibration of two objective measures of physical activity for children. *J Sports Sci*. (2008) 26 (14):1557–65. doi: 10.1080/02640410802334196

46. Pate RR, Almeida MJ, McIver KL, Pfeiffer KA, Dowda M. Validation and calibration of an accelerometer in preschool children. *Obesity (Silver Spring)*. (2006) 14(11):2000–6. doi: 10.1038/oby.2006.234

47. Li J, Shao W. Influence of sports activities on prosocial behavior of children and adolescents: a systematic literature review. *Int J Environ Res Public Health*. (2022) 19 (11):6484. doi: 10.3390/ijerph19116484

48. Bang F, Roberts KC, Chaput JP, Goldfield GS, Prince SA. Physical activity, screen time and sleep duration: combined associations with psychosocial health among Canadian children and youth. *Health Rep*. (2020) 31(5):9–16. doi: 10.25318/82-003-x202000500002-eng

49. Guerrero MD, Barnes JD, Chaput JP, Tremblay MS. Screen time and problem behaviors in children: exploring the mediating role of sleep duration. *Int J Behav Nutr Phys Act*. (2019) 16(1):105. doi: 10.1186/s12966-019-0862-x

50. Sampasa-Kanyinga H, Colman I, Goldfield GS, Janssen I, Wang J, Tremblay MS, et al. 24-Hour Movement behaviors and internalizing and externalizing behaviors among youth. *J Adolesc Health*. (2021) 68(5):969–77. doi: 10.1016/j.jadohealth.2020.09.003

51. Goldstein AN, Walker MP. The role of sleep in emotional brain function. *Annu Rev Clin Psychol*. (2014) 10:679–708. doi: 10.1146/annurev-clinpsy-032813-153716

52. Ranum BM, Wichstrom L, Pallesen S, Falch-Madsen J, Halse M, Steinsbekk S. Association between objectively measured sleep duration and symptoms of psychiatric disorders in middle childhood. *JAMA Netw Open*. (2019) 2(12): e1918281. doi: 10.1001/jamanetworkopen.2019.18281

53. Viner RM, Gireesh A, Stiglic N, Hudson LD, Goddings AL, Ward JL, et al. Roles of cyberbullying, sleep, and physical activity in mediating the effects of social media use on mental health and wellbeing among young people in England: a secondary analysis of longitudinal data. *Lancet Child Adolesc Health*. (2019) 3(10):685–96. doi: 10.1016/S2352-4642(19)30186-5

54. Twenge JM, Hisler GC, Krizan Z. Associations between screen time and sleep duration are primarily driven by portable electronic devices: evidence from a population-based study of U.S. Children ages 0–17. *Sleep Med*. (2019) 56:211–8. doi: 10.1016/j.sleep.2018.11.009

55. Guerrero MD, Barnes JD, Walsh JJ, Chaput JP, Tremblay MS, Goldfield GS. 24-hour movement behaviors and impulsivity. *Pediatrics*. (2019) 144(3):e20190187. doi: 10.1542/peds.2019-0187

56. Ogundele MO. Behavioural and emotional disorders in childhood: a brief overview for paediatricians. *World J Clin Pediatr*. (2018) 7(1):9–26. doi: 10.5409/wjcp.v7.i1.9

57. Caprara GV, Kanacri BPL, Gerbino M, Zuffianò A, Alessandri G, Vecchio G, et al. Positive effects of promoting prosocial behavior in early adolescence. *Int J Behav Dev*. (2014) 38(4):386–96. doi: 10.1177/0165025414531464

58. Moeijes J, Van Busschbach JT, Lockhart KL, Bosscher RJ, Twisk JWR. Characteristics of sports participation and psychosocial health in children: results of a cross-sectional study. *Eur J Sport Sci*. (2019) 19(3):365–74. doi: 10.1080/17461391.2018.1510988

59. Lee O, Park M, Jang K, Park Y. Life lessons after classes: investigating the influence of an afterschool sport program on adolescents' life skills development. *Int J Qual Stud Health Well-Being*. (2017) 12(1):1307060. doi: 10.1080/17482631.2017.1307060

60. McNeill J, Howard SJ, Vella SA, Cliff DP. Compliance with the 24-hour movement guidelines for the early years: cross-sectional and longitudinal associations with executive function and psychosocial health in preschool children. *J Sci Med Sport*. (2020) 23(9):846–53. doi: 10.1016/j.jsams.2020.02.011

61. Hinkley T, Timperio A, Watson A, Duckham RL, Okely AD, Cliff D, et al. Prospective associations with physiological, psychosocial and educational outcomes of meeting Australian 24-hour movement guidelines for the early years. *Int J Behav Nutr Phys Act*. (2020) 17(1):36. doi: 10.1186/s12966-020-00935-6

62. Gao Z, Liu W, McDonough DJ, Zeng N, Lee JE. The dilemma of analyzing physical activity and sedentary behavior with wrist accelerometer data: challenges and opportunities. *J Clin Med*. (2021) 10(24):5951. doi: 10.3390/jcm10245951