



24-H movement behaviours research in Chinese population: A scoping review

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ARTICLE INFO

Keywords:

24-H movement guidelines

Physical activity

Sedentary behaviour

Sleep

China

ABSTRACT

Background: Numerous studies examining 24-h movement behaviours have been exponentially published globally. However, no comprehensive reviews summarized and synthesized the evidence on the Chinese population. This review aimed to map the most recent research state and fill the gaps related to 24-h movement behaviours in the Chinese population.

Methods: Five electronic databases (Web of Science, PubMed, Scopus, EBSCOhost, and CNKI (Chinese database)) were searched from their inceptions through October 2023. Quantitative studies published in English and/or Chinese were included if they were related to 24-h movement behaviours in the Chinese population.

Results: From 9431 documents screened, 53 met the inclusion criteria. All the included studies were published between 2019 and 2023, showing a notable increasing trend over the years. Most studies used cross-sectional designs (96.2 %) and self-reported measures (56.6 %). Nearly all the studies targeted general healthy population (96.2 %), especially children and adolescents (64.2 %). The main three research topics observed were health outcomes (81.1 %), prevalence (66.0 %), and correlates (15.1 %) of 24-h movement behaviours.

Conclusion: 24-h movement behaviours in the Chinese population has been an increasingly important research topic in the literature, with predominant focus on children and adolescents (study population), self-report measure (measurement), cross-sectional design (study design), guidelines adherence (study topic), and health outcomes examination (study topic). These findings delineate a research landscape in the Chinese population, and highlight the research gaps needed to be addressed. Future studies are suggested to target these research gaps, expanding evidence base for the Chinese populations. For instance, more studies using device-based measures, longitudinal or interventional designs, as well as qualitative and mixed-methods approaches are required.

1. Introduction

Physical activity, sedentary behaviour and sleep (collectively referred to 24-h movement behaviours) are co-dependent behaviours making up the whole 24-h day.^{1,2} A large number of studies have demonstrated that the mutually exclusive and exhaustive nature of these

behaviours results in an equal and opposite change in either of the behaviours if there is an increase in time spent in one behaviour.^{3–6} Accordingly, there has been a shift in studying these behaviours in combination given that no single behaviour can buffer the adverse effects of the others.^{7,8} While independent health benefits of sufficient physical activity,^{9,10} limited sedentary time,^{9,11} and optimal sleep

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<https://doi.org/10.1016/j.jesf.2024.07.005>

Received 2 May 2024; Received in revised form 30 July 2024; Accepted 30 July 2024

Available online 31 July 2024

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duration^{12,13} have been studied, increasing evidence shows that their combined effects on physical, cognitive, and mental health would be stronger than either of these behaviours in isolation.^{14–19}

Currently, research has been increasingly focused on studying 24-h movement behaviours using an integrative perspective.^{20–22} To achieve using the integrative approach, researchers primarily tend to use either the 24-h movement guidelines (as a research paradigm)^{23–26} or compositional data analysis.^{27–29} Studies based on the 24-h movement guidelines focus on examining the proportion of meeting the guidelines and the associations with factors and health outcomes. By contrast, the compositional data analysis can be used to examine the effect of reallocations between time spent in physical activity, sedentary behaviour, and sleep on various health indicators. These two research methods help researchers accumulate a great deal of evidence regarding 24-h movement behaviours, including measurement and assessment,^{30–32} prevalence and trends,^{33–35} correlates and determinants,^{36–38} health outcomes and interventions.^{39–43} Of note, the accumulated evidence predominantly stems from studies conducted in high-income countries, especially in those that have developed the 24-h movement guidelines such as Australia and Canada.^{23–25,44} On the contrary, studies conducted in the low- and middle-income countries (LMICs) are relatively scarce, highlighting the need for examination of the evidence on 24-h movement behaviours in such countries and regions. As one of the LMICs, China has been suffering from the health burden of unhealthy 24-h movement behaviours over the past decades.^{45,46} Recent surveys show that the prevalence of meeting the 24-h movement guidelines is extremely low in the Chinese population, indicating unhealthy movement behaviours. For example, a survey based on the 2017 Youth Study in China of 114,072 children and adolescents found that only 5.12 % of them met all three 24-h movement guidelines.⁴⁷ Similarly, a survey of 2002 Chinese participants reported that only 15.1 % of adults met all three guidelines.⁴⁸ These concerning data demonstrate a need to enhance 24-h movement behaviours in the Chinese population for health promotion.

In response to significant public health challenges, the Chinese government has launched initiatives to ease adverse health impacts and address related issues, such as the Healthy China 2030 Blueprint⁴⁹ and the National Fitness Program (2021–2025).⁵⁰ These key policy initiatives highlight the importance of encouraging healthy lifestyles (e.g., 24-h movement behaviours) as a primary strategy for health improvement, with a strong political willingness and long-lasting commitment. To better achieve the goals and guide future research, it is important to know what the current situation is regarding the 24-h movement behaviours literature in the Chinese population as it would provide valuable guidance and potential enhancements to the effectiveness of planned actions.

In addition, over the past decade, epidemiological studies of physical activity, sedentary behaviour, and sleep have been on the rise. Several previous reviews have examined the prevalence, correlates, and health outcomes of these movement behaviours in isolation in the Chinese population.^{51–53} Concurrently, while there has been consistent growth in literature addressing 24-h movement behaviours,^{47,54} no review has been conducted to examine the entire 24-h movement behaviours in the Chinese population. Scoping reviews are a useful method for mapping the evidence in a given research area, which is useful in identifying gaps in the literature and prioritized areas for future research, policy and practice.⁵⁵ Therefore, the aim of this scoping review was to map the evidence on 24-h movement behaviours in Chinese population.

2. Materials and methods

This scoping review adhered to established process for conducting such a study.^{56,57} The process includes six stages: Stage 1 focuses on identifying the research question (Introduction), such as clearly state the research question, purpose, and specify population, concept, and context; Stage 2 involves identifying relevant studies (Methods),

developing a plan for where to search, which terms to use, which sources to search, time span, and language; Stage 3 encompasses study selection (Methods), defining the eligibility criteria and selection process; Stage 4 involves charting the data (Results), a “narrative review” or “descriptive analytical” method is adopted to extract contextual or process-oriented information from each study; Stage 5 focuses on summarizing and reporting the findings (Discussion), discussing the findings as they relate to the research purpose and implications for future study, practice and policy; Stage 6 involves consultation (Conclusion), such as incorporates knowledge from experts and other key stakeholder.

2.1. Search strategy

The databases searched included Web of Science, PubMed, Scopus, EBSCOhost, and CNKI covering studies from their inception to October 2023. The search strategy incorporated two main keywords: “24-h movement behaviours” and “Chinese population”. The detailed search strategies used for each database can be found in [Supplementary Table S1](#). Additionally, the reference lists of the included studies and the authors’ personal library were screened to identify any eligible records. All records were imported into the EndNote X9 software (Thomson Research Soft, Stanford, CA, USA) for screening. After removing the duplicates, two authors (JH and HF) independently screened the titles and abstracts of identified records. They then screened the full text of potential records and identified eligible studies for inclusion in this scoping review. Any disagreements between these authors were resolved through discussion with the third author (SC) until agreement was reached.

2.2. Eligibility criteria

Studies meeting the following criteria were included in this scoping review: 1) studies targeting the Chinese population living in China; 2) studies focusing on 24-h movement behaviours, including physical activity, screen time and sedentary behaviour (children and adolescents) or sedentary behaviour (adults), and sleep; 3) based on the *Framework for Viable Integrative Research in Time-Use Epidemiology* (VIRTUE framework),² studies quantitatively examining or studying correlates/determinants, prevalence, measurement, and outcomes related to 24-h movement behaviours; 4) observational (e.g., cross-sectional, longitudinal) and/or experimental (interventional) studies; 5) peer-reviewed articles published in either Chinese or English. Studies were excluded if they targeting the Chinese population residing outside of China or if they were literature reviews, commentaries, conference abstracts, or editorials.

2.3. Data extraction

The following information was extracted from each included study: 1) general details, including first author names and year of publication, 2) sample characteristics encompassing gender, age, sample size, and subpopulation groups (e.g., preschool children, children and adolescents, adults, older adults), 3) study design (e.g., cross-sectional, longitudinal, experimental) and sampling methods, 4) study measurement details, including measurement methods (e.g., self-administered, device-based) and measurement tools, 5) study topics including correlates/determinants, prevalence, measurement, and outcomes associated with 24-h movement behaviours. Data extraction was independently performed by two authors (JH and HF). Any discrepancies between these authors were resolved through discussion, with consensus reached with the involvement of the third author (SC).

2.4. Data synthesis

Descriptive analysis (such as frequency, percentage) was used to synthesize the extracted data. Specifically, we counted the number of

publications per year on 24-h movement behaviours in the Chinese population, and the number and proportion of publications for different study designs, age groups, groups with health conditions, measurement tools, correlates, and health indicators. For example, age groups were classified as preschool children, children and adolescents, adult, and older. Based on the VIRTUE framework,² correlates of 24-h movement behaviours were grouped into socio-demographic, behavioural and lifestyle, environmental and knowledge factors. Health outcomes were further categorized as health and functioning, psychological, behavioural and lifestyle, and skills and abilities. The prevalence of meeting the entire 24-h movement guidelines was summarized separately according to different age groups.

3. Results

3.1. Study selection

A total of 9431 records were identified through searches of five electronic databases. Following the removal of 4330 duplicates, the remaining 5101 articles were screened based on their title and abstract. Of these, 5032 were excluded for not meeting the eligibility criteria. Subsequently, 59 articles underwent full-text screening, and 49 of them met the inclusion criteria. Four additional studies were identified through manual searches, leading to a final inclusion of 53 articles in this scoping review (Fig. 1).

3.2. General bibliometric information of the included studies

As shown in Fig. 2, all the included studies spanned from 2019 to 2023, witnessing a notable increase in publications on 24-h movement behaviours in the Chinese populations over the years. Following the publication of two articles in 2019^{58, 59}, there has been a sharp increase in publications in subsequent years, peaking at 20 articles in 2022. Despite the study search being conducted in October 2023, the number of studies remained substantial in this year.

The characteristics of the study design and sample are presented in Table 1. Out of the 53 included studies, 51 used a cross-sectional design,

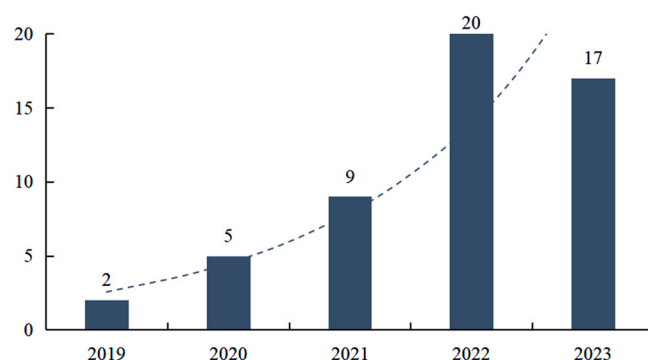


Fig. 2. Yearly publication number of studies on 24-h movement behaviours.

Table 1
Characteristics of the study design and sample.

Categorization	No. of studies	%
Study Design		
Cross-sectional studies	51	96.2 %
Longitudinal studies	2	3.8 %
Sample by sex		
Female and male	53	100 %
Sample by health condition		
General population	51	96.2 %
People with health conditions	2	3.8 %
Sample by age		
Preschool Children	10	19.2 %
Children and Adolescents	34	64.2 %
Adults	8	15.4 %
Older Adults	1	2.4 %

whereas two utilized a longitudinal design. The total sample sizes of the included studies ranged from 99 to 114,072, totalling 510,667 participants. Seven out of the 53 studies conducted secondary data analyses of national surveys using nationally representative samples, including the

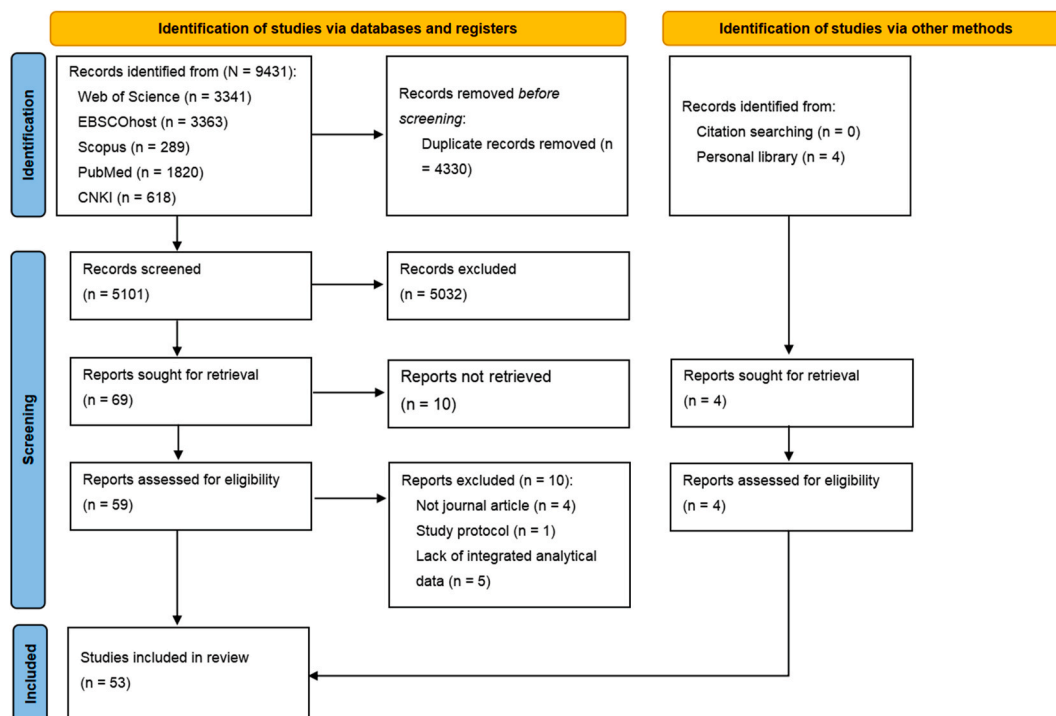


Fig. 1. Flow chart of the study selection.

Physical Activity and Fitness in China—The Youth Study,⁴⁷ the China National Nutrition and Health Surveillance in 2010–2012,⁶⁰ the Preschool Children National Fitness Status Survey,⁶¹ the China Common Disease and Risk Factor Surveillance among Students,⁶² the National Fitness Status Survey in 2020,⁶³ and the National Health Lifestyle Intervention Program.⁶⁴

All the included studies comprised participants of both sexes, with females accounting for 50.3 % of the total sample. Regarding studied population subgroups, 51 studies focused on the generally healthy population, while two studies each targeted children with autism spectrum disorder and children and adolescents with intellectual disability.^{65,66} Regarding sample age groups, 34 studies involved children and adolescents, 10 targeted preschool children, eight concerned adults, and only one contained older adults.⁶⁷

3.3. Measurement of 24-h movement behaviours

Measurement and assessment methods used in the included studies are summarized in Fig. 3. Self-report questionnaires were the predominant measure (n = 30), followed by device-based measures (n = 9) and parental report questionnaires (n = 3). Of note, 11 studies used mixed methods, with six studies incorporating both device-based and parental report measures, and five utilizing both device-based measures and self-report questionnaires. Several specific questionnaires were commonly used, including the International Physical Activity Questionnaire (IPAQ) and the Pittsburgh Sleep Quality Index (PSQI). Furthermore, some studies used self-administered questions or selected items from the standardized surveys (public data), such as the Health Behaviour in School-aged Children Survey^{47,68} and the China National Nutrition and Health Surveillance.⁶⁰

3.4. Study topics of 24-h movement behaviours research

Three main research topics, including correlates/determinants, health outcomes, and time-use composition are identified in this review (Table 2 and Fig. 4). Eight out of 53 included studies examined the correlates/determinants of 24-h movement behaviours (i.e., guidelines adherence) and were categorized into four major categories: socio-demographic (n = 8), behavioural and lifestyle (n = 1), environmental (n = 1), and knowledge (n = 1). Some studies examined multiple correlates, resulting in a total exceeding eight.⁶¹ In terms of health outcomes, 43 studies examined the relationships between 24-h movement behaviours and various health outcomes, categorized as follows: health and functioning (n = 23), psychological (n = 15), behavioural and lifestyle (n = 4), and skills and abilities (n = 3). Health and functioning outcomes primarily encompassed measures related to overweight or obesity, such as body mass index (BMI), weight status, and body composition. Psychological outcomes primarily included anxiety and depression. Behavioural and lifestyle outcomes encompassed internet addiction, smartphone addiction, and bullying. Skills and abilities

Table 2

Number of studies examining the correlates and outcomes of 24-h movement behaviours.

Categorization	Correlates (n = 8)		Categorization	Outcomes (n = 43)	
	No. of studies	%		No. of studies	%
Socio-demographic factors	8	100 %	Health and functioning	23	53.5 %
Behavioural and lifestyle factors	1	12.5 %	Psychological outcomes	15	34.1 %
Environmental factors	1	12.5 %	Behavioural and lifestyle outcomes	4	9.5 %
Knowledge factors	1	12.5 %	Skills and abilities	3	7.1 %

Note. Some studies examined multiple correlates/outcomes, resulting in a total exceeding 8/43.

outcomes primarily focused on physical fitness and fundamental movement skills. For the research topic of time-use composition, 35 studies reported the prevalence of meeting the three 24-h movement guidelines. Specifically, the prevalence of adherence to 24-h movement guidelines varied from 2.9 % to 16.4 % in preschool children (n = 6), 0.3 %–26.1 % in children and adolescents (n = 25), 15.1 %–27 % in adults (n = 3), and 1.61 % in older adults (n = 1).⁶⁷

4. Discussion

4.1. Findings summary

To the best of our knowledge, this is the first scoping review to summarize the current evidence on 24-h movement behaviours research in the Chinese population. The key findings of this review are as follows. First, since 2019, there has been growing research attention on 24-h movement behaviours in the Chinese population. Second, children and adolescents were the main study population, and most of the studies adopted self-report measures and a cross-sectional design. Third, the prevalence of meeting the 24-h movement guidelines in the Chinese population was relatively low and greatly varied across age groups. Finally, according to the VIRTUE framework,² studies focusing on the prevalence and level, and health outcomes emerged as the two dominant research topics, whereas relatively limited studies examined correlates. These findings can provide meaningful messages for guiding future research and practice in the field of 24-h movement behaviours.

4.2. Trends in publications of 24-h movement behaviours studies

The increasing number of research publications (between 2019 and 2023) in 24-h movement behaviours suggests a growing research interest in the Chinese population. Since the first physical activity study using compositional data analysis was published in 2015,⁶⁹ and the release of the first 24-h movement guidelines in 2016²⁵, research on 24-h movement behaviours has become an important topic in the public health related research. These two milestone studies laid the scientific foundations for subsequent research on 24-h movement behaviours. Inspired by these studies, the first set of 24-h movement behaviour studies in the Chinese population was published in 2019.^{58,59} Since the development in the research field, our scoping review found there were 53 studies on 24-h movement behaviours in the Chinese population, demonstrating significant research attention and commitment. Of note, few included studies employed compositional data analysis. This may limit quantitative understanding of the effects of interactions between physical activity, sedentary behaviour and sleep and their impact on health outcomes in the Chinese population. Moreover, while the included studies were conducted with the Chinese population, most of

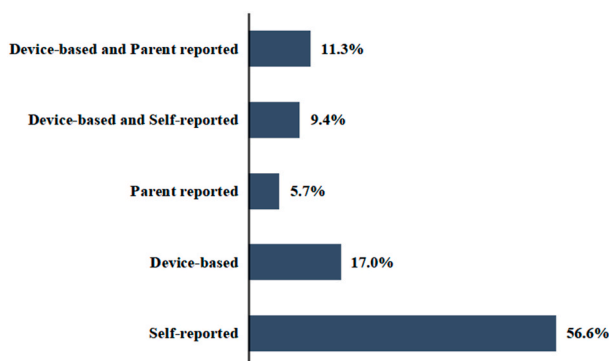


Fig. 3. Frequency of measurements of 24-h movement behaviours.

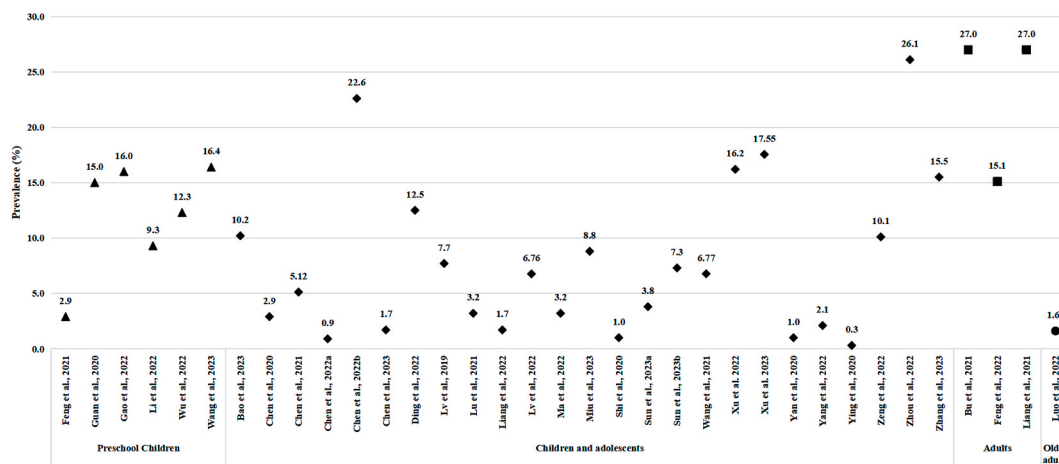


Fig. 4. Prevalence of meeting the 24-h movement guidelines.

them adhered to the Canadian 24-h movement guidelines. This finding implies that researchers should develop 24-h movement guidelines tailored specifically for the Chinese populations, as this would be an effective framework or approach to promote healthy movement behaviours in China.⁷⁰

4.3. Designs and measures of 24-h movement behaviours studies

The results of this review indicated that nearly all the included studies used a cross-sectional design. This finding is consistent with previous reviews on physical activity or/and sedentary behaviour in Asian countries, such as Indonesia, Thailand, and Bangladesh.^{71–73} Given the limited time and funding invested in physical activity related research in LMICs, including China, it is understandable that cross-sectional studies involving 24-h movement behaviours are more feasible. Although cross-sectional designs offer some advantages, they can hardly establish cause-and-effect associations, thereby limiting the certainty of evidence. Therefore, more 24-h movement behaviours studies using longitudinal or interventional study designs are need. Additionally, qualitative or mixed-method designs were not observed in the included studies of this review. Qualitative or mixed-method designs can contribute to a deeper understanding of interpreting 24-h movement behaviours. Although, several studies have begun to examine 24-h movement behaviours using mixed methods, these studies are not specifically targeted the Chinese population.^{74,75} Hence, future research on 24-h movement behaviours in the Chinese population should consider using diverse research methods to accumulate enriched evidence base.

Similar to previous reviews that explored physical activity or/and sedentary behaviour in specific populations,^{53,72} our review found that self-reported questionnaires were the most widely used instrument to assess 24-h movement behaviours. Although the limitations of self-reported questionnaires have been clearly documented (e.g., measurement errors, social desirability bias),⁷⁶ their widespread use in population-based surveys remains internationally popular.^{77,78} By contrast, device-based measures (e.g., accelerometers, pedometers) can provide more reliable and valid data. However, only a few studies in this review used device-based measures to assess 24-h movement behaviours. Several studies suggested that researchers in high-income countries were more likely to use device-based measures,^{79,80} possibly due to greater investments in their research compared to those conducted in LMICs.⁷³ While device-based measures have some inherent disadvantages in assessing particular types of screen time, such as television viewing, they hold strong potential for the use in large-scale studies, surveillance, and monitoring. It is therefore suggested that, if possible, future studies should consider incorporating device-based measures to assess 24-h movement behaviours in the Chinese populations.

4.4. Study populations in 24-h movement behaviour studies

Children and adolescents were the most commonly studied population group in 24-h movement behaviour studies in the Chinese population. This finding is in agreement with the international research trend in 24-h movement behaviours research.^{33,41} Two potential reasons can be proposed for this pattern. The first one is that the initial 24-h movement guidelines were designed for children and adolescents and were released in 2016²⁵, whereas the guidelines for adults were published in 2020.⁸¹ Second, children and adolescents are a priority population for public health and physical activity related research globally,⁸² which may have influenced the emphasis on this population in 24-h movement behaviours research. Taken together, these reasons may explain why the included studies prioritized children and adolescents over adults or other study populations.

Moreover, the majority of the included studies (96 %) in this review focused on general healthy population while only a few studies targeted people with health conditions.^{65,66} This finding is consistent with a recent scoping review examining sedentary behaviour in the Chinese population.⁵³ One possible reason may be that conducting research on the general healthy population is more convenient in terms of research procedures (e.g., ethics application and sample recruitment) compared to the studies involving people with health conditions. The Canadian 24-h movement guidelines declare that these recommendations are also appropriate for people with disabilities or medical conditions,²⁵ but there are currently only a handful of studies globally that focused on 24-h movement behaviours in people with health conditions. For instance, a recent systematic review found that only approximately 24 studies worldwide have examined 24-h movement behaviours in people with disabilities,⁸³ which is substantially fewer than those involving generally healthy population. Given these observations, researchers should focus more on people with health conditions and further examine the applicability and trustworthiness of the 24-h movement guidelines in this group.

4.5. Study topics in 24-h movement behaviours studies

Based on the VIRTUE framework,² the current review summarized the research topics of the studies included in this review. Findings indicate that studies on prevalence and health outcomes of 24-h movement behaviours were predominant, followed by correlates, which is similar to previous research on physical activity, sedentary behaviour, and sleep epidemiology conducted in isolation.^{71,84,85} Indeed, these three domains also represent the greatest interests of scholars in the field of time-use epidemiology research.^{64,71,84,85}

In the present review, the prevalence of meeting 24-h movement

guidelines was relatively low in the Chinese population across different age groups and varied greatly among the studies. Specifically, the prevalence of meeting 24-h movement guidelines ranged from 2.9 % to 16.4 % in preschool children, 0.3 %–26.1 % in children and adolescents, 15.1 %–27 % in adults, and 1.61 % in older adults. The relatively low compliance rate may be attributed to changes in people's lifestyles over the past decade with China's rapid economic development, such as the popularity of electronic devices, changes in transportation modes, and increased pressure from work and school, leading to an increase in physical inactivity and sedentary behaviour.⁸⁶ Similar variation in the prevalence of meeting 24-h movement guidelines has been reported in a previous systematic review using global samples.³³ Such variations in the prevalence may be owing to the use of different instruments to assess 24-h movement behaviours across age groups.

A majority of the included studies in this review examined the association between 24-h movement behaviours and health outcomes, with a particular emphasis on health and functioning (e.g., physical fitness, overweight/obesity) and psychological health (e.g., anxiety, depression). This finding is consistent with previous studies of 24-h movement behaviours in other countries.^{16,20} This finding was expected as physical and mental health outcomes are of great public health importance for governments and researchers globally, particularly among children and adolescents. In response to these health problems, the Chinese government has implemented various measures, such as promoting physical activity participation⁷⁰ and the National Fitness Program.⁵⁰

Regarding the correlates of 24-h movement behaviours in the Chinese population, the most studies focused on sociodemographic factors (e.g., age, gender, education level), while only a very limited number assessed factors from other domains, such as behaviour and lifestyle, environment, and knowledge. This finding is supported by previous reviews,³³ and may be attributed to the relative ease of data collection for sociodemographic factors. Furthermore, this finding is also similar to the evidence from previous research on sedentary behaviour in the Chinese population,⁵³ indicating that sociodemographic factors have become central in 24-h movement behaviours research. However, it is important to note that sociodemographic factors are non-modifiable variables, limiting the potential to change 24-h movement behaviours. Collectively, it is clear that future studies should aim to explore a wider range of factors affecting 24-h movement behaviours from different domains, especially those that are modifiable (e.g., motivation, support, knowledge). A comprehensive understanding of the complex interactions between movement behaviours and different factors can help provide more robust evidence for future interventions.

4.6. Strengths and limitations

Some study strengths of this scoping review are worth mentioning. First, this review included studies published in English or Chinese, which expands the pool of eligible studies. Second, this review outlines research topics on several aspects including prevalence, health outcomes, and determinants/correlates based on the VIRTUE framework.² Third, while there is increasing evidence on the topic from high-income countries, this review maps the evidence from one of the LMICs (i.e., China). However, some limitations this review should be acknowledged. Due to the inherent heterogeneity (e.g., different measures and different age groups) for 24-h movement behaviours research in China, an in-depth evaluation of each study was not possible. As a result, this review primarily described the relevant characteristics of the included studies.

4.7. Recommendations for future research

Based on the above analysis, some recommendations can be proposed for future research in the Chinese population.

4.7.1. Recommendation 1: development of comprehensive surveillance and monitoring systems for 24-h movement behaviours

Owing to the beneficial associations 24-h movement behaviours and health indicators,^{16,87,88} it is necessary to establish a surveillance and monitoring system to identify “at-risk” population who have unhealthy 24-h movement behaviours, thereby facilitating target interventions to improve population health. Similar to the National Fitness Surveillance and Monitoring Project in China,⁸⁹ relevant stakeholders should conduct periodic surveillance on the 24-h movement behaviours of the Chinese population. In addition, a 24-h movement behaviours database of the Chinese population should be established based on the surveillance and monitoring systems. These efforts would provide valuable data to researchers and policymakers to improve behavioural health in the Chinese population.

4.7.2. Recommendation 2: strengthening and extending the evidence base according to the VIRTUE framework

Guided by the VIRTUE framework,² the present review identified main topics of research on 24-h movement behaviours in the Chinese population encompassed health outcomes, time-use composition, and correlates/determinants. However, in addition to these aspects, the VIRTUE framework also includes methods (e.g., measurement, surveillance, and data processing) and time-use interventions (e.g., using behavioural, environmental, or policy interventions to achieve the optimal time-use balance).² Therefore, future research is encouraged to conduct research that receives less attention according to this framework such as time-use interventions. This proliferation would benefit the 24-h movement behaviours research in the Chinese population.

4.7.3. Recommendation 3: development of 24-h movement guidelines for the Chinese population

Researchers predominantly rely on the Canadian guidelines to conduct 24-h movement behaviours research in the Chinese population. Taking the country-specific contextual factors into account, there is an urgent need for policymakers, scholars and relevant stakeholders to develop 24-h movement guidelines tailored specifically for the Chinese population. The development process of guidelines should be scientific, rigorous and transparent to ensure high-quality evidence. Therefore, it is imperative to collect the existing scientific literature on physical activity, sedentary behaviour, and sleep in the Chinese population as the foundational evidence for formulating the Chinese 24-h movement guidelines. However, the development of the Chinese 24-h movement guidelines is only the first step. Subsequently, researchers should conduct more relevant studies in the Chinese people based on these guidelines.

4.7.4. Recommendation 4: implementation of 24-h movement behaviours interventions

This review did not find any intervention studies aimed to improving the 24-h movement behaviours in the Chinese population. Due to the real-world complexity and contextual differences, interventions to improve the 24-h movement behaviours face certain challenges. Most interventions, to date, in the Chinese people targeted one or two movement behaviours rather than addressing the entire 24-h movement spectrum.⁹⁰ To promote physical activity and sleep and reduce sedentary behaviour in the Chinese population, collaborative efforts are needed to design and develop a comprehensive intervention protocol. There is also a need to develop family, school, and community-based intervention strategies to support healthy 24-h movement behaviours in the Chinese population.

4.7.5. Recommendation 5: expanding the study populations within 24-h movement behaviours research

To date, 24-h movement behaviours research has predominantly focused on the general healthy population, especially children and adolescents. Future studies, therefore, should expand their focus to include

other age groups, such as adults and older adults. With China's population aging, promoting healthy aging has become a pivotal initiative of the Chinese government. Thus, increasing research on the 24-h movement behaviours of older adults could significantly contribute to achieving this objective. Moreover, current evidence on 24-h movement behaviours in populations with special needs, such as individuals with disabilities or chronic diseases, is extremely limited. These groups typically have higher health risks and demonstrate lower adherence to the 24-h movement guidelines. Therefore, it is crucial for future research to prioritize these subpopulations.

5. Conclusions

This scoping review provides a comprehensive summary of the evidence from studies on 24-h movement behaviours in the Chinese population, providing a knowledge base for future research direction and policy development. This review reveals an increasing trend in the number of articles published on 24-h movement behaviours in recent years, with a predominant focus on children and adolescents, self-report measure, cross-sectional design, guidelines adherence, and health outcomes. However, there remains much space for improvement in current research on 24-h movement behaviours, particularly in terms of study design, study populations, measurement methods, and study topics. By implementing the recommendations provided in this review, future studies may provide more robust evidence necessary to inform public health efforts aimed at promoting healthy 24-h movement behaviours in the Chinese population.

Author contribution

Writing-original draft preparation: JH, ARM, and RB; Literature search and inclusion, Data extraction and analysis: JH, HF, SC; Review and Editing, Supervision: LW, YL, SC, and CL; Conceptualisation and Methodology: LW, SC, and CL.

All the authors approved manuscript before submission and publication.

Declaration of interest statement

The authors declare that they have no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jesf.2024.07.005>.

References

- Pedisic Z. Measurement issues and poor adjustments for physical activity and sleep undermine sedentary behaviour research—the focus should shift to the balance between sleep, sedentary behaviour, standing and activity. *Kinesiology*. 2014;46:135–146.
- Pedisic Z, Dumuid D, Olds T. Integrating sleep, sedentary behaviour, and physical activity research in the emerging field of time-use epidemiology: definitions, concepts, statistical methods, theoretical framework, and future directions. *Kinesiology*. 2017;49.
- Best JR, Falck RS, Landry GJ, Liu-Ambrose T. Analysis of dynamic, bidirectional associations in older adult physical activity and sleep quality. *J Sleep Res*. 2019;28:e12769.
- Daly-Smith AJ, Zwolinsky S, McKenna J, Tomporowski PD, Defeyter MA, Manley A. Systematic review of acute physically active learning and classroom movement breaks on children's physical activity, cognition, academic performance and classroom behaviour: understanding critical design features. *BMJ Open Sport Exerc Med*. 2018;4, e000341.
- Voss MW, Carr LJ, Clark R, Weng T. Revenge of the "sit" II: does lifestyle impact neuronal and cognitive health through distinct mechanisms associated with sedentary behavior and physical activity? *Ment Health Phys Act*. 2014;7:9–24.
- Wang F, Boros S. The effect of physical activity on sleep quality: a systematic review. *Europ J Physiother*. 2021;23:11–18.
- Ekelund U, Tarp J, Fagerland MW, et al. Joint associations of accelerometer-measured physical activity and sedentary time with all-cause mortality: a harmonised meta-analysis in more than 44 000 middle-aged and older individuals. *Br J Sports Med*. 2020;54:1499–1506.
- Mellow ML, Crozier AJ, Dumuid D, et al. How are combinations of physical activity, sedentary behaviour and sleep related to cognitive function in older adults? a systematic review. *Exp Gerontol*. 2022;159, 111698.
- Rodriguez-Ayllon M, Cadenas-Sánchez C, Estévez-López F, et al. Role of physical activity and sedentary behavior in the mental health of preschoolers, children and adolescents: a systematic review and meta-analysis. *Sports Med*. 2019;49:1383–1410.
- Poitras VJ, Gray CE, Borghese MM, 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:S197–S239.
- Carson V, Hunter S, Kuzik N, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update. *Appl Physiol Nutr Metab*. 2016;41:S240–S265.
- Chaput JP, Gray CE, Poitras VJ, et al. Systematic review of the relationships between sleep duration and health indicators in school-aged children and youth. *Appl Physiol Nutr Metab*. 2016;41:S266–S282.
- Vestergaard CL, Skogen JC, Hysing M, Harvey AG, Vedaa Ø, Sivertsen B. Sleep duration and mental health in young adults. *Sleep Med*. 2024;115:30–38.
- Baillot A, Chaput JP, Prince SA, Romain AJ, Colley RC, Lang JJ. Health associations with meeting the new Canadian 24-Hour Movement Guidelines recommendations according to body mass index classes in Canadian adults. *Health Rep*. 2022;33:3–15.
- Leppänen MH, Haapala EA, Väistö J, et al. Longitudinal and cross-sectional associations of adherence to 24-hour movement guidelines with cardiometabolic risk. *Scand J Med Sci Sports*. 2022;32:255–266.
- Rollo S, Antsygina O, Tremblay MS. The whole day matters: understanding 24-hour movement guideline adherence and relationships with health indicators across the lifespan. *J Sport Health Sci*. 2020;9:493–510.
- Rollo S, Lang JJ, Roberts KC, et al. Health associations with meeting the Canadian 24-hour movement guidelines for adults: results from the Canadian Health Measures Survey. *Health Rep*. 2022;33:16–26.
- Sampasa-Kanyinga H, Colman I, Goldfield GS, et al. Combinations of physical activity, sedentary time, and sleep duration and their associations with depressive symptoms and other mental health problems in children and adolescents: a systematic review. *Int J Behav Nutr Phys Act*. 2020;17:72.
- Badon SE, Ferrara A, Gabriel KP, Avalos LA, Hedderson MM. Changes in 24-hour movement behaviors from early to late pregnancy in individuals with prepregnancy overweight or obesity. *J Phys Act Health*. 2022;19:842–846.
- Groves CI, Huong C, Porter CD, et al. Associations between 24-h movement behaviors and indicators of mental health and well-being across the lifespan: a systematic review. *JASSB*. 2024;3:9.
- Zahran S, Visser C, Ross-White A, Janssen I. A systematic review of compositional analysis studies examining the associations between sleep, sedentary behaviour, and physical activity with health indicators in early childhood. *JASSB*. 2023;2:1.
- Bao R, Chen S, Zou L. Is adherence to the 24-h movement guidelines associated with greater academic-related outcomes in children and adolescents? a systematic review and meta-analysis. *Eur J Pediatr*. 2024;183:2003–2014.
- Loo BKG, Okely AD, Pulungan A, Jalaludin MY. Asia-Pacific Consensus Statement on integrated 24-hour activity guidelines for children and adolescents. *Br J Sports Med*. 2022;56:539–545.
- Okely AD, Ghersi D, Loughran SP, et al. A collaborative approach to adopting/adapting guidelines. The Australian 24-hour movement guidelines for children (5-12 years) and young people (13-17 years): an integration of physical activity, sedentary behaviour, and sleep. *Int J Behav Nutr Phys Act*. 2022;19:2.
- Tremblay MS, Carson V, Chaput JP, 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:S311–S327.
- Tremblay MS. Introducing 24-Hour movement guidelines for the early years: a new paradigm gaining momentum. *J Phys Act Health*. 2020;17:92–95.
- Grgic J, Dumuid D, Bengoechea EG, et al. Health outcomes associated with reallocations of time between sleep, sedentary behaviour, and physical activity: a systematic scoping review of isotemporal substitution studies. *Int J Behav Nutr Phys Act*. 2018;15:69.
- Mota JG, Clark CCT, Bezerra TA, et al. Twenty-four-hour movement behaviours and fundamental movement skills in preschool children: a compositional and isotemporal substitution analysis. *J Sports Sci*. 2020;38:2071–2079.
- Swindell N, Rees P, Fogelholm M, et al. Compositional analysis of the associations between 24-h movement behaviours and cardio-metabolic risk factors in overweight and obese adults with pre-diabetes from the PREVIEW study: cross-sectional baseline analysis. *Int J Behav Nutr Phys Act*. 2020;17:12.
- Zheng J, Tan TC, Zheng K, Huang T. Development of a 24-hour movement behaviors questionnaire (24HMBQ) for Chinese college students: validity and reliability testing. *BMC Publ Health*. 2023;23:752.
- Arts J, Chinapaw M, Gubbels J, et al. Development and content validity of an application to assess 24-hour movement behaviors in 0–4-year-old children involving end-users and key stakeholders: the My Little Moves app. *Int J Behav Nutr Phys Act*. 2024;21.
- Rodrigues B, Encantado J, Carraça E, et al. Questionnaires measuring movement behaviours in adults and older adults: content description and measurement properties. A systematic review. *PLoS One*. 2022;17, e0265100.

33. Tapia-Serrano MA, Sevil-Serrano J, Sánchez-Miguel PA, López-Gil JF, Tremblay MS, García-Hermoso A. Prevalence of meeting 24-Hour Movement Guidelines from preschool to adolescence: a systematic review and meta-analysis including 387,437 participants and 23 countries. *J Sport Health Sci.* 2022;11:427–437.
34. Manyanga T, Barnes JD, Chaput JP, Katzmarzyk PT, Prista A, Tremblay MS. Prevalence and correlates of adherence to movement guidelines among urban and rural children in Mozambique: a cross-sectional study. *Int J Behav Nutr Phys Act.* 2019;16:94.
35. Pearson N, Sherar LB, Hamer M. Prevalence and correlates of meeting sleep, screen-time, and physical activity guidelines among adolescents in the United Kingdom. *JAMA Pediatr.* 2019;173:993–994.
36. Buchan C, Carson V, Faulkner G, Qian W, Leatherdale S. Factors associated with students meeting components of Canada's new 24-hour movement guidelines over time in the COMPASS study. *Int J Environ Res Public Health.* 2020;17:5326.
37. Christian H, Murray K, Trost SG, et al. Meeting the Australian 24-hour movement guidelines for the early years is associated with better social-emotional development in preschool boys. *Prev Med Rep.* 2022;27, 101770.
38. Hedayatrad L, Stewart T, Paine SJ, Marks E, Walker C, Duncan S. Sociodemographic differences in 24-hour time-use behaviours in New Zealand children. *Int J Behav Nutr Phys Act.* 2022;19:131.
39. Marques A, Ramirez-Campillo R, Gouveia E, et al. 24-hour movement guidelines and overweight and obesity indicators in toddlers children and adolescents: a systematic review and meta-analysis. *Sports Med Open.* 2023;9:30.
40. Rodrigo-Sanjoaquin J, Bois JE, Aibar Solana A, Lhuisset L, Corral-Abós A, Zaragoza Casterad J. Are school-based interventions promoting 24-hour movement guidelines among children? a scoping review. *Health Edu J.* 2023, 001789692311654.
41. Wilhite K, Booker B, Huang BH, et al. Combinations of physical activity, sedentary behavior, and sleep duration and their associations with physical, psychological, and educational outcomes in children and adolescents: a systematic review. *Am J Epidemiol.* 2023;192:665–679.
42. Jiang S, Ng JYY, Chong KH, Peng B, Ha AS. Effects of ehealth interventions on 24-hour movement behaviors among preschoolers: systematic review and meta-analysis. *J Med Internet Res.* 2024;26, e52905.
43. Walters AJ, Lithopoulos A, Tennant EM, Weissman S, Latimer-Cheung AE. Exploring attention to the Canadian 24-hour movement guidelines for children and youth using eye-tracking: a randomized control trial. *Public Health Nurs.* 2022;39:982–992.
44. O'Neill CD, Vidal-Almela S, Terada T, et al. Moving together while staying apart: practical recommendations for 24-hour home-based movement behaviours for those with cardiovascular disease. *CJC Open.* 2021;3:1495–1504.
45. Wang D, Zheng W, Wang SM, et al. Estimation of cancer incidence and mortality attributable to overweight, obesity, and physical inactivity in China. *Nutr Cancer.* 2012;64:48–56.
46. Shao T, Wang L, Chen H. Association between sedentary behavior and obesity in school-age children in China: a systematic review of evidence. *Curr Pharm Des.* 2020; 26:5012–5020.
47. Chen ST, Liu Y, Tremblay MS, 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;10:349–359.
48. Feng J, Huang WY, Lau PWC, Wong SH, Sit CH. Movement behaviors and mental health of caregivers of preschoolers in China during the COVID-19 pandemic. *Prev Med.* 2022;155, 106913.
49. Chen P, Li F, Harmer P. Healthy China 2030: moving from blueprint to action with a new focus on public health. *Lancet Public Health.* 2019;4:e447.
50. Menhas R, Dai J, Ashraf MA, et al. Physical inactivity, non-communicable diseases and national fitness plan of China for physical activity. *Risk Manag Healthc Policy.* 2021;14:2319–2331.
51. Zhang C-Q, Chung P-K, Cheng S, et al. An update on physical activity research among children in Hong Kong: a scoping review. *Int J Environ Res Public Health.* 2020;17:8521.
52. Li L, Li L, Chai JX, et al. Prevalence of poor sleep quality in patients with hypertension in China: a meta-analysis of comparative studies and epidemiological surveys. *Front Psychiatry.* 2020;11:591.
53. Bao R, Chen ST, Wang Y, et al. Sedentary behavior research in the Chinese population: a systematic scoping review. *Int J Environ Res Public Health.* 2020;17.
54. Liang K, Chen S, Chi X. Differential associations between meeting 24-hour movement guidelines with mental wellbeing and mental illness among Chinese adolescents. *J Adolesc Health.* 2023;72:658–666.
55. Memon AR, Stanton R, To Q, et al. Sedentary behaviour research in adults: a scoping review of systematic reviews and meta-analyses. *J Sports Sci.* 2021;39:2219–2231.
56. Peters MD, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. *Int J Evid Based Healthc.* 2015;13:141–146.
57. Tricco AC, Lillie E, Zarin W, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med.* 2018;169:467–473.
58. Lv Y, Cai L, Zeng X, et al. Levels and correlates of 24-hour movement behaviors in Chinese children aged 6–13 years. *Chinese J School Health.* 2019;40:1791–1795.
59. Tan k, Lai L, Cai L, Zhang J, Tan W, Chen Y. Association of Different Activity Behaviors with Body Composition Among Children Aged 6 to 12 Years in Guangzhou. 2019: 1775–1779.
60. Ding C, Fan J, Yuan F, et al. Association between physical activity, sedentary behaviors, sleep, diet, and adiposity among children and adolescents in China. *Obes Facts.* 2022;15:26–35.
61. Gao W, Zhang Y, Wu D, Dong Y, Liu N, Wang H. Compliance with health-related behaviors guidelines and its relationship with multiple factors in preschool children aged 3–6 years: a national cross-sectional survey in China. *Int J Environ Res Public Health.* 2022;19.
62. Sun W, Li J, Zhou J, et al. Meeting the Canadian 24-hour movement guidelines and physical-mental comorbidity among Chinese children and adolescents: prevalence, associations, and the population impacts. *J Psychosom Res.* 2024;176, 111544.
63. Wang H, Zhang Y, Wu D, et al. Empowerment through digital technology for higher-level development of rural public sports service: theoretical interpretation and practical pathway. *China Sport Sci.* 2023;43:26–33.
64. Yang Y, Yuan S, Liu Q, et al. Meeting 24-hour movement and dietary guidelines: prevalence, correlates and association with weight status among children and adolescents: a national cross-sectional study in China. *Nutrients.* 2022;14.
65. Xu W, Qi J. Meeting 24-hour movement guidelines: their relationships with overweight and obesity among Chinese children with autism spectrum disorder. *Res Autism Spectr Disord.* 2022;99, 102066.
66. Xu W, Wang L. Adherence to 24-h movement guidelines among Chinese children and adolescents with intellectual disabilities. *J Intellect Disabil Res.* 2023;67(7): 668–678.
67. Luo L, Cao Y, Hu Y, et al. The associations between meeting 24-hour movement guidelines (24-HMG) and self-rated physical and mental health in older adults-cross sectional evidence from China. *Int J Environ Res Public Health.* 2022;19.
68. Bao R, Yang Z, Memon AR, Chen S, Wang L, Cai Y. Association between meeting the 24-h movement guidelines and psychosocial health in children: a cross-sectional study. *Child Care Health Dev.* 2024;50(1), e13191.
69. Chastin SF, Palarea-Albaladejo J, Dontje ML, Skelton DA. Combined effects of time spent in physical activity, sedentary behaviors and sleep on obesity and cardio-metabolic health markers: a novel compositional data analysis approach. *PLoS One.* 2015;10, e0139984.
70. Chen S, Ma J, Hong J, et al. A public health milestone: China publishes new physical activity and sedentary behaviour guidelines. *JASSB.* 2022;1:9.
71. Andriyani FD, Biddle SJH, Arovah NI, Cocker K. Physical activity and sedentary behavior research in Indonesian youth: a scoping review. *Int J Environ Res Public Health.* 2020;17.
72. Liangruenrom N, Craike M, Biddle SJH, Suttikasem K, Pedisic Z. Correlates of physical activity and sedentary behaviour in the Thai population: a systematic review. *BMC Publ Health.* 2019;19:414.
73. Uddin R, Hasan M, Saif-Ur-Rahman KM, Mandic S, Khan A. Physical activity and sedentary behaviour in Bangladesh: a systematic scoping review. *Publ Health.* 2020; 179:147–159.
74. Draper CE, Silubonde TM, Mukoma G, van Sluijs EMF. Perceptions of the South African 24-Hour movement guidelines for birth to 5 years: a qualitative study. *J Phys Act Health.* 2022;19:4–11.
75. Dalziel A, Janssen X. Barriers and facilitators of physical activity, sedentary and sleep behaviours in 3 to 4-year-old children from low-income families: a study protocol. *JASSB.* 2023;2.
76. Matthews CE, Moore SC, George SM, Sampson J, Bowles HR. Improving self-reports of active and sedentary behaviors in large epidemiologic studies. *Exerc Sport Sci Rev.* 2012;40:118–126.
77. Arts J, Gubbels JS, Verhoeff AP, Chinapaw MJM, Lettink A, Altenburg TM. A systematic review of proxy-report questionnaires assessing physical activity, sedentary behavior and/or sleep in young children (aged 0–5 years). *Int J Behav Nutr Phys Act.* 2022;19:18.
78. Pedišić Z, Bauman A. Accelerometer-based measures in physical activity surveillance: current practices and issues. *Br J Sports Med.* 2015;49:219–223.
79. Lee IM, Shiroma EJ. Using accelerometers to measure physical activity in large-scale epidemiological studies: issues and challenges. *Br J Sports Med.* 2014;48:197–201.
80. Migueles JH, Cadenas-Sanchez C, Ekelund U, et al. Accelerometer data collection and processing criteria to assess physical activity and other outcomes: a systematic review and practical considerations. *Sports Med.* 2017;47:1821–1845.
81. Ross R, Chaput JP, Giangregorio LM, et al. Canadian 24-hour movement guidelines for adults aged 18–64 years and adults aged 65 years or older: an integration of physical activity, sedentary behaviour, and sleep. *Appl Physiol Nutr Metab.* 2020;45: S57–S102.
82. Messing S, Rütten A, Abu-Omar K, et al. How can physical activity be promoted among children and adolescents? a systematic review of reviews across settings. *Front Public Health.* 2019;7:55.
83. Huang J, Li X, Li G, et al. Prevalence of meeting 24-hour movement guidelines and its associations with health indicators in people with disabilities: a systematic review and meta-analysis. *Disability Health J.* 2024, 101616.
84. Chen X, Ke Z, Chen Y, Lin X. The prevalence of sleep problems among children in mainland China: a meta-analysis and systemic-analysis. *Sleep Med.* 2021;83: 248–255.
85. Paterson DC, Ramage K, Moore SA, Riaz N, Tremblay MS, Faulkner G. Exploring the impact of COVID-19 on the movement behaviors of children and youth: a scoping review of evidence after the first year. *J Sport Health Sci.* 2021;10:675–689.
86. Tu WJ, Sun H, Yan F, et al. China trends in physical inactivity from 2013 to 2019: an analysis of 4.23 million participants. *Med Sci Sports Exerc.* 2024;56:528–535.
87. López-Gil JF, Tapia-Serrano MA, Sevil-Serrano J, Sánchez-Miguel PA, García-Hermoso A. Are 24-hour movement recommendations associated with obesity-related indicators in the young population? a meta-analysis. *Obesity.* 2023;31(11): 2727–2739.

88. Miatke A, Olds T, Maher C, et al. The association between reallocations of time and health using compositional data analysis: a systematic scoping review with an interactive data exploration interface. *Int J Behav Nutr Phys Act.* 2023;20:127.
89. Liu Z, Zhang S, Li L, et al. Research on the construction and prediction of China's national fitness development index system under social reform. *Front Public Health.* 2022;10, 878515.
90. Lai A, Stewart S, Wan A, et al. Development and feasibility of a brief zero-time exercise intervention to reduce sedentary behaviour and enhance physical activity: a pilot trial. *Health Soc Care Community.* 2019;27:e233–e245.