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Compliance with the 24-hour movement behaviour guidelines among children and adolescents with disabilities: a systematic review and meta-analysis

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Abstract

Background Compliance with the 24-Hour Movement Guidelines (24-HMG: physical activity (PA), screen time (ST), and sleep) has been associated with numerous beneficial health outcomes among children and adolescents. However, there is a lack of consensus on the overall compliance with the 24-HMG specifically among children and adolescents with disabilities. Therefore, this systematic review and meta-analysis aimed to examine the extent to which children and adolescents with disabilities adhere to the 24-HMG globally.

Method Quantitative studies published in English until May 2023 were sought by searching seven electronic databases: Web of Science, PubMed, SPORTDiscus, CINAHL, MEDLINE, Scopus, Psychology and Behavioural Sciences Collection. This review included studies that identified participants as individuals with disabilities and reported the overall (non) compliance with the 24-HMG among children and adolescents with disabilities.

Results A total of 13 studies, involving 21,101 individuals (65.95% males), aged 6 to 21 years from 9 countries, were included in the analysis. In general, 7% (95%CI: 0.05–0.09, $p < 0.01$) of children and adolescents with disabilities met all three 24-HMG, while 16% (95%CI: 0.13-020, $p < 0.01$) did not meet any of the three recommendations. Regarding adherence to individual 24-hour movement behaviour, the rates of compliance were 22% (95%CI: 0.18–0.25, $p < 0.01$) for PA, 49% (95%CI: 0.41–0.56, $p < 0.01$) for ST, and 59% (95%CI: 0.56–0.61, $p < 0.01$) sleep. In relation to numbers of those meeting the 24-HMG, 43% (95%CI: 0.41–0.45, $p < 0.01$) met one guideline, while 32% (95%CI: 0.28–0.36, $p < 0.01$) met two guidelines.

Conclusion There is a notable percentage of children and adolescents with disabilities who do not meet the recommended the 24-HMG, which encompasses PA, ST, and sleep. This underscores the pressing requirement to create and execute evidence-based strategies that effectively encourage and assist these individuals with disabilities in adopting and maintaining these movement behaviours.

Keywords Children and adolescent, Disabilities, Movement behaviours, Physical activity, Sedentary behaviour, Sleep

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Introduction

Extensive studies have highlighted that regular physical activity (PA), minimizing sedentary behaviour (SB), and adequate sleep are independently associated with favourable health outcomes in children and adolescents [1–3], including lower risk of disease [4–7], better physical fitness [8], greater psychosocial health [9, 10] and improved motor skills [11]. Considering the dynamic interplay and interrelationships of the three behaviours, to maximize overall health, there was a need to introduce a novel movement paradigm that integrates PA, SB, and sleep over a whole day [12]. In 2016, the pioneering Canadian 24-Hour Movement Guidelines (24-HMG) for children and adolescents was released, which provided guidance on the amount of time spent in all intensities of PA, SB and sleep to optimize health benefits [13]. The 24-HMG offer evidence-based recommendations for children and adolescents to ensure a well-balanced 24-hour period, including an accumulation of at least 60 min of moderate-to-vigorous PA, no more than two hours of recreational ST, and uninterrupted 9 to 11 h of sleep for children (6–12 years) and 8 to 10 h for adolescents (13–18 years) [13]. Following this, United States [14], Australia [15], New Zealand [16] and the Asia-Pacific region [17] also gradually developed or adopted the 24-HMG for children and youth, alongside Canada. Sufficient PA, reduced SB and adequate sleep have been demonstrated as the optimal combination for promoting overall health in children and adolescents. Adherence to the 24-HMG is associated with higher multiple health indicators, including reduced adiposity [18], lower cardiometabolic risk [19], enhanced global cognition [14], better mental health [20], decreased risk of internalizing and externalizing behaviours [21], improved executive function [22], higher academic achievement [23], and better quality of life [24], compared to those who meet fewer or none of these guidelines.

Meeting the recommendations within the 24-HMG poses greater challenges for children and adolescents with disabilities compared to their peers without disabilities. This heightened difficulty arises from the nature of disability, which can encompass a wide range of conditions, including physical, sensory, intellectual, or mental health impairments [25, 26]. Meanwhile, disability is frequently viewed as a social construct because it is not solely determined by an individual's physical or mental characteristics, but also by how society perceives and responds to those characteristics [27]. To put it differently, disability encompasses not only an individual's impairment or condition but also the barriers and discrimination they encounter in society due to those impairments [28]. These barriers and discrimination can manifest as physical (such as lack of accessibility) [29], attitudinal (such as stereotypes and prejudice) [30], or systemic (such as policies that exclude or marginalize people with disabilities) [31]. Notably, research findings consistently indicate that children and adolescents with disabilities, particularly those with attention deficit hyperactivity disorder [32, 33], autism spectrum disorder [34, 35], and cognitive difficulties [36], exhibit lower rates of meeting the recommendations within the 24-HMG, which highlights that children and adolescents with disabilities are often at a greater risk for health issues. Supporting positive 24-hour behaviour changes in children and adolescents is one potential way to reduce these inequalities. Therefore, it is essential to examine adherence to the 24-HMG in children and adolescents with disabilities.

However, to date, no systematic review and meta-analysis has been conducted to specifically synthesize the adherence rate to the 24-HMG among children and adolescents with disabilities - despite the growing body of literature on adherence to the 24-HMG among typically developing children and adolescents [37, 38]. For example, a recent review that incorporated 63 studies, 387,437 participants and 23 countries revealed that 7.12% of youth met all three 24-HMG, and 19.21% meet none of the 3 recommendations [39]. These figures highlight the general difficulty of adherence in typically developing children and adolescents, this challenge is likely even more pronounced among peers with disabilities. With nearly 240 million children and adolescents with disabilities worldwide [40], there is a critical need to investigate the status of their compliance with the 24-HMG and possibly the need to prioritize it, since adherence to the overall 24-HMG was associated with better health related-outcomes in individuals with disabilities [35, 41–44]. Therefore, this systematic review and meta-analysis aimed to synthesize the existing literature on adherence to the 24-HMG among children and adolescents with disabilities, bridging a research gap and offering evidence-based insights for fostering optimal health and well-being in this underserved population.

Materials and methods

Registration and protocol

The present systematic review and meta-analysis was conducted following the guidelines of the Preferred Reporting Items for Systematic Review and Meta-Analysis guidelines (PRISMA) [45]. And the protocol was registered at the International Prospective Register of Systematic Reviews (PROSPERO; registration no. CRD42023441111).

Information sources and search strategy

A thorough search was carried out using seven electronic databases: Web of Science, PubMed (NIBI), SPORTDiscus (EBSCO), CINAHL (EBSCO), MEDLINE (EBSCO), Scopus and Psychology and Behavioural Sciences Collection (EBSCO), for relevant publications up to May 2023. Furthermore, we manually reviewed the reference lists of the retrieved articles and systematic reviews to identify any potentially missed relevant studies. A list of key search terms and alternative key search terms were created, combined together using Boolean operators ('AND', 'OR'), and included in the aforementioned databases for the search. Table 1 provides more details regarding the strategy employed for selecting key search terms. The initial step involved exporting all references to EndNote X9 software, where duplicates were identified and eliminated through a combination of software functionality and manual inspection of the citation list. Subsequently, articles were evaluated for eligibility based on their title and abstract, using the predefined inclusion criteria. Lastly, full-text articles were acquired for studies that met the criteria or could not be excluded solely based on title and abstract. Throughout the process, reasons for excluding articles were carefully documented. Two reviewers (HYR and ZXG) independently determined the studies to be included based on the predefined inclusion and exclusion criteria. Any disagreements between the reviewers were resolved through discussion, and a final decision was reached with the involvement of a third reviewer (RR). The entire search process was conducted on June 20th, 2023.

Selection procedure and eligibility criteria

PICOS provides a structured format to define the key components of the research question: Population, Intervention, Comparison, Outcomes, and Study Design [46]. This precision ensures that the research question is specific and well-defined, especially in systematic reviews and meta-analyses [39, 47]. Studies had to fulfil following criteria concerning PICOS criteria: (1) population: population of children and adolescents aged between 5 and 17 years, or with a mean/ median sample age between 5 and 17 years; participants with disabilities including physical, sensory, cognitive and developmental disabilities; without limit on the multiple disabilities; (2) outcomes: assessed PA, ST and sleep, meeting none of the guidelines, one of the guidelines, two of the guidelines and all three of the 24-HMG; (3) study design: observational, cross-sectional, and longitudinal studies, and intervention studies were included as long as they provided pertinent baseline data; (4) articles published in a peer-reviewed journal with full-text in English between June 16th, 2016 and June 1st, 2023.

The exclusion criteria were defined as follows: (1) studies focusing solely on overweight or obese children and adolescents with disabilities; (2) studies where the title, abstract, or main text explicitly indicated that data collection occurred during the COVID-19 lockdown periods, COVID-19-related lockdowns had a detrimental effect on the movement behaviours of children and adolescents, with stricter lockdowns having a more significant impact [48], which altered behaviours may not reflect typical patterns, introducing potential biases into the analysis; (3) studies based on data from the same surveys or studies to prevent duplication (4) systematic reviews and/or meta-analyses, qualitative and case studies, grey literature, master/ doctoral dissertation, conference articles, and abstracts, comments and press releases, unpublished articles; (5) articles not written in English and (6) articles published prior to June 16th, 2016 because the initial 24-HMG for children and youth were introduced in June 16th, 2016.

Data collection process and data items

Data were extracted and presented based on previous reviews [49–51], and the data were organized in Microsoft Excel 2016 (Microsoft Corp, Washington US). Data extraction involved the utilization of a standardized

Table 1 Key search terms strategy in databases

Search	Term	Search strategy
1	24-hour movement behaviour	'movement behavior*' OR '24-h*' OR 'physical activit*' OR screen* OR sleep*
2	Children and adolescents	child* OR adolescen* OR youth OR teenager* OR student* OR school OR 'school*aged' OR '5–17 years' OR juvenile
3	Disabilities	disab* OR 'physical disabilit*' OR 'developmental disabilit*' OR 'developmental delay' OR 'learning disabilit*' OR 'intellectual disabilit*' OR 'mental* retard*' OR 'down syndrome' OR DS OR 'autism spectrum disorder*' OR 'attention deficit hyperactivity disorder*' OR ADHD OR 'cerebral palsy' OR 'tourette syndrome' OR 'neurocognitive disorder*' OR 'neurocognitive disabilit*' OR 'cognitive impairment*' OR 'cognitive dis*' 'acquired brain injur*' OR 'motor skills disorder*' OR 'developmental coordination disorder*' OR 'sensory impairment*' OR 'emotional impairment*' OR deafness OR blindness OR 'language disorder*' OR special
4	S1 AND S2 AND S3	

extraction form, and the full texts of the selected studies were independently reviewed by two reviewers (HYR and ZXG). One reviewer (HYR) performed the information extraction from the chosen articles, while another reviewer (ZXG) verified the data for accuracy. In the event of disagreements between the two reviewers, a third reviewer (RR) resolved the discrepancies. All relevant studies underwent meticulous scrutiny to extract various data points, including author(s) name, publication year, geographic location, study design, participant characteristics, sampling time points, main findings, and quality assessment score. Formal data extraction was conducted from June 21st, 2023, and data extraction ended on June 29^{th,} 2023.

Risk of bias assessment

To prevent bias in the assessment of the methodological quality of the articles included in this review, information regarding the author(s), affiliations, date, and source of each study was concealed. Methodological quality was assessed using the Standard Quality Assessment Criteria for Evaluating Primary Research Papers from a Variety of Fields [52]. The quantitative checklist was selected as the most appropriate tool for assessing studies with various designs. This assessment tool comprises a 14-item checklist, as outlined in Table 2. Each item was assigned a score: yes = 2, partial = 1, no = 0, or N/A where applicable. The final quality assessment score was determined as a percentage of the relevant items achieved, with any N/A scores excluded from this calculation. Therefore, the exclusion of "N/A" scores from these calculations provides comparable quality scores between studies, regardless of design. Two reviewers (HYR and ZXG) independently evaluated the methodological quality of the included studies, classifying them as high quality, medium quality, or low quality. Discrepancies in quality assessment were resolved by a third reviewer (RR). Quality was scored as a percentage of the criteria met, enabling comparison of quality across all included studies. Score ranges were categorized into the following 3 categories for these cross-sectional studies: "high quality" (> 75%), "medium quality" (scores of 55–75%), and "low quality" (scores of < 55%) [53].

Synthesis methods

The meta-analysis was conducted using Stata version 17.0 (StataCorp, College Station, TX, USA). A random-effects meta-analysis was employed to estimate the pooled compliance rate of children and adolescents with disabilities in achieving the 24-hour movement behaviour recommendation. The primary outcome assessed in the meta-analysis was the proportion of individuals meeting all the 24-HMG. Additionally, a random-effects analysis of variance model, specifically designed for meta-analytic research, was used to compare adherence to the 24-HMG across different types of guideline adherence (none, one, two, or all guidelines). The assessment of guideline adherence (none, one, two, or all guidelines) was conducted by utilizing the raw numerators and denominators derived from data obtained in the included studies. Initially, we extracted the essential data directly from the included studies

Table 2 Quality assessment checklist of quantitative studies

Criteria	Yes	Partial	No	*N/A*
1. Question or objective sufficiently described?				
2. Design evident and appropriate to answer study question?				
3. Method of subject selection (and comparison group selection, if applicable) or source of information/input variables (e.g., for decision analysis) is described and appropriate.				
4. Subject (and comparison group, if applicable) characteristics or input variables/information (e.g., for decision analyses) sufficiently described?				
5. If random allocation to treatment group was possible, is it described?				
6. If interventional and blinding of investigators to intervention was possible, is it reported?				
7. If interventional and blinding of subjects to intervention was possible, is it reported?				
8. Outcome and (if applicable) exposure measure(s) well defined and robust to measurement / misclassification bias? Means of assessment reported?				
9. Sample size appropriate?				
10. Analysis described and appropriate?				
11. Some estimate of variance (e.g., confidence intervals, standard errors) is reported for the main results/outcomes (i.e., those directly addressing the study question/objective upon which the conclusions are based)?				
12. Controlled for confounding?				
13. Results reported in sufficient detail?				
14. Do the results support the conclusions?				

whenever accessible. In instances where the required data was not explicitly provided in the included studies, we employed mathematical calculations to derive the necessary results indirectly. This involved utilizing available data from the included studies, such as tables and figures. The adherence of the outcome and corresponding 95% confidence intervals were reported. The I^2 statistic and its associated p-value were used to assess the consistency and heterogeneity of the pooled proportions [54]. It should be noted that qualitative assessment of publication bias is not recommended in proportional meta-analyses [55].

Results

Selection of studies

Initially, a total of 5401 potentially eligible articles were identified from six electronic databases ($n=5391$) and other sources ($n=10$). Following the removal of 1,591 duplicates, 3,800 articles remained. Subsequently, after screening the titles and abstracts, 3,743 articles were excluded, and an additional six articles were excluded as the full reports could not be retrieved. A further 51 articles were excluded after their full texts were screened. Four articles were included via citation searching. Finally, 13 published articles met the inclusion criteria and were included in this systematic review and meta-analysis. Figure 1 illustrates the PRISMA flow diagram of the search and screening process.

Quality assessment

Full-quality assessment scores are presented in Table 3. The maximum points that a study could receive was 1. Higher scores indicate better quality of the study. The quality scores of all studies ranged from 0.65 to 1. Specifically, eleven (81.62%) of the studies were considered 'high quality; and two (15.38%) were considered 'medium quality'. In general, the quality of all included studies was assessed as high. Because of these high ratings, it is assumed that study quality will not impact the results, and therefore, the results have not been stratified based on quality assessment scores. All studies (100%) sufficiently described the objectives and questions. They were designed to be easily identified and appropriate to address the research questions/objectives. Most studies met the reporting criteria regarding the method of subject selection (92.31%), demographic information, and descriptions of the participants' characteristics (76.92%). Since all included studies had a cross-sectional design, Items 5, Item 6, and Item 7 were not applicable. In the outcome, most studies indicated defined outcome(s) and exposure measure(s). A small number of studies (38.46%) had larger sample sizes ($n>1000$), nevertheless, the sample sizes of a few studies (23.07%) were probably inadequate ($n<100$). Most studies described analytical methods and provided appropriate variances estimate(s). Few studies (15.38%) indicated information about controlled for confounding, such as BMI z-score, received higher scores, yet Item 12 does not apply to more than

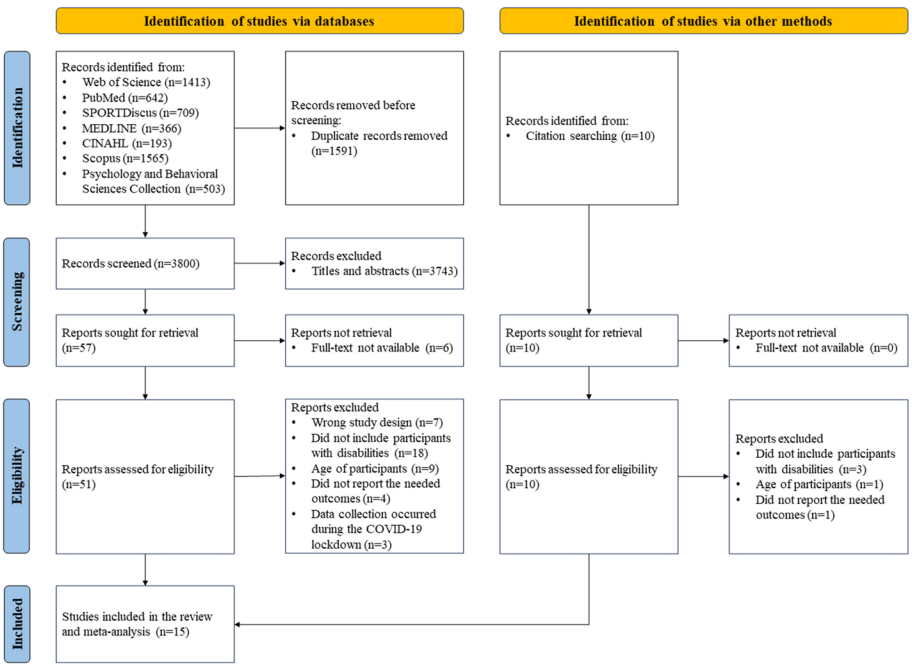

Fig. 1 The PRISMA flow diagram of the search and screening process

Table 3 Quality assessment of included studies

Author(s)	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13	Item 14	Total Score	Quality
Healy et al.	Y	Y	Y	Y	N/A	N/A	N/A	Y	Y	Y	Y	N/A	Y	Y	1.00	High (100%)
Haegele et al.	Y	Y	Y	Y	N/A	N/A	N/A	Y	P	Y	Y	N/A	Y	Y	0.95	High (95%)
Healy et al.	Y	Y	Y	P	N/A	N/A	N/A	Y	N	Y	Y	P	P	Y	0.77	High (77%)
Arbour-Nicitopoulos et al.	Y	Y	Y	P	N/A	N/A	N/A	Y	N	Y	Y	N/A	Y	Y	0.85	High (85%)
Brown et al.	Y	Y	Y	Y	N/A	N/A	N/A	P	Y	Y	P	P	P	P	0.77	High (77%)
Brown and Ronen	Y	Y	Y	Y	N/A	N/A	N/A	P	P	Y	Y	Y	P	Y	0.86	High (86%)
Haegele et al.	Y	Y	Y	Y	N/A	N/A	N/A	Y	Y	Y	Y	P	Y	Y	0.95	High (95%)
Li et al.	Y	Y	Y	Y	N/A	N/A	N/A	Y	Y	Y	Y	Y	Y	Y	1.00	High (100%)
Wang et al.	Y	Y	P	Y	N/A	N/A	N/A	P	P	P	P	N/A	Y	Y	0.68	Medium (68%)
Xu and Qi	Y	Y	Y	P	N/A	N/A	N/A	P	N	P	Y	N/A	P	Y	0.65	Medium (65%)
Kong et al.	Y	Y	Y	Y	N/A	N/A	N/A	Y	P	Y	Y	P	Y	Y	0.91	High (91%)
Taylor et al.	Y	Y	Y	Y	N/A	N/A	N/A	Y	Y	P	Y	N/A	Y	Y	0.95	High (95%)
Xu and Wang	Y	Y	Y	Y	N/A	N/A	N/A	P	P	Y	Y	N/A	P	Y	0.85	High (85%)

Y Yes, *P* Partial, *N* No

Table 4 Descriptive characteristics of included studies($n = 13$)

Author(s) (year)	Country	Study Design	Participants			Measurement of Movement Behaviours			Main Findings
			Sample Size	Age (years)	Disability Type	PA Measure	ST Measure	SD Measure	
Healy et al. (2019) [34]	United States	Cross-sectional quantitative study	1008	6–17	Autism spectrum disorder	Parental proxy-reports	Parental proxy-reports	Parental proxy-reports	1) Meets PA recommendations (17.34%) 2) Meets ST recommendations (65.81%) 3) Meets SD recommendations (56.53%) 4) Number of recommendations met (0: 12.28%; 1: 43.83%; 2: 38.85%; 3: 5.64%)
Haegele et al. (2020) [59]	United States	Cross-sectional quantitative study	561 Male (44.1%) Female (55.9%)	10–17 (13.80 ± 2.33)	Visual impairments	Parental proxy-reports	Parental proxy-reports	Parental proxy-reports	1) Meets PA recommendations (18.70%) 2) Meets ST recommendations (73.20%) 3) Meets SD recommendations (50.70%) 4) Number of recommendations met (0: 10.60%; 1: 44.40%; 2: 39.10%; 3: 5.80%)
Healy et al. (2020) [58]	Ireland	Cross-sectional quantitative study	36 Male (88.9%) Female (11.1%)	9	Autism spectrum disorder	Parental proxy-reports	Parental proxy-reports	Parental proxy-reports	1) Meets PA recommendations (41.70%) 2) Meets ST recommendations (58.30%) 3) Meets SD recommendations (77.80%) 4) Number of recommendations met (0: 0.00%; 1: 38.90%; 2: 44.40%; 3: 16.70%)
Arbour-Nicitopoulos et al. (2021) [60]	Canada	Cross-sectional quantitative study	54 Male (40.7%) Female (59.3%)	12–21 (17.4 ± 2.8)	Visual impairment, Cerebral palsy, Spinal cord injury, Muscular dystrophy, Neuromuscular disorder, Amputation, and other	Self-reports	Self-reports	Self-reports	1) Meets PA recommendations (55.50%) 2) Meets ST recommendations (13.00%) 3) Meets SD recommendations (53.70%) 4) Number of recommendations met (0: 18.50%; 1: 44.50%; 2: 33.30%; 3, 3.70%)

Table 4 (continued)

Author(s) (year)	Country	Study Design	Participants			Measurement of Movement Behaviours			Main Findings
			Sample Size	Age (years)	Disability Type	PA Measure	ST Measure	SD Measure	
Brown et al. (2021) [61]	United States	Cross-sectional quantitative study	8554 Male (62.7%) Female (37.3%)	6–17 (11.5)	Neurodevelopmental disorders (Deafness, Blindness, Cerebral palsy, Down syndrome, Developmental delay, Intellectual disability, Learning disability, Autism spectrum disorder, Attention deficit disorder/attention deficit hyperactivity disorder, Epilepsy, Tourette syndrome, Speech disorder)	Parental/caregiver proxy-reports	Parental/caregiver proxy-reports	Parental/caregiver proxy-reports	1) Meets PA recommendations (21.20%) 2) Meets ST recommendations (47.60%) 3) Meets SD recommendations (57.60%) 4) Number of recommendations met (0: 21.00%; 1: 40.20%; 2: 30.10%; 3: 8.70%)
Brown and Ronen (2021) [62]	United States	Cross-sectional quantitative study	663 Male (49.5%) Female (50.5%)	6–17 (11.27)	Epilepsy	Parental/caregiver proxy-reports	Parental/caregiver proxy-reports	Parental/caregiver proxy-reports	1) Meets PA recommendations (16.30%) 2) Meets ST recommendations (43.90%) 3) Meets SD recommendations (60.50%) 4) Number of recommendations met (0: 20.10%; 1: 45.60%; 2: 28.70%; 3: 5.60%)
Haegele et al. (2021) [63]	United States	Cross-sectional quantitative study	3582 Male (65.3%) Female (34.7%)	10–17 (13.25 ± 2.27)	Not mentioned, participants receiving special education services	Parental proxy-reports	Parental proxy-reports	Parental proxy-reports	1) Meets PA recommendations (20.90%) 2) Meets ST recommendations (66.30%) 3) Meets SD recommendations (59.20%) 4) Number of recommendations met (0: 11.90%; 1: 38.00%; 2: 42.00%; 3: 8.10%)

Table 4 (continued)

Author(s) (year)	Country	Study Design	Participants			Measurement of Movement Behaviours			Main Findings
			Sample Size	Age (years)	Disability Type	PA Measure	ST Measure	SD Measure	
Li et al. (2022) [35]	Seven-country (Brazil, Finland, Hong Kong, Mainland China, Singapore, South Korea, and the United States)	Cross-sectional quantitative study	Total: $n=1165$; Male (75.6%) Female (24.4%) Brazil: $n=228$; Male (87.3%) Female (12.7%) Finland: $n=278$ Male (66.5%) Female (33.5%) Hong Kong, China: $n=96$ Male (88.5%) Female (11.5%) Mainland China $n=186$ Male (82.3%) Female (17.7%) Singapore: $n=89$ Male (79.8%) Female (20.2%) South Korea: $n=202$ Male (61.9%) Female (38.1%) United States: $n=86$ Male (73.3%) Female (26.7%)	10–17 (13.08 ± 2.18) Brazil (13.01 ± 2.09) Finland (13.34 ± 2.06) Hong Kong (13.50 ± 2.50) Mainland China (12.43 ± 2.15) Singapore (13.20 ± 2.62) South Korea (13.01 ± 2.06) United States (13.34 ± 2.01)	Autism spectrum disorder	Parental proxy-reports	Parental proxy-reports	Parental proxy-reports	Total 1) Meets PA recommendations (7.20%) 2) Meets ST recommendations (46.40%) 3) Meets SD recommendations (55.90%) 4) Number of recommendations met (0: 21.50%; 1: 49.40%; 2: 27.00%; 3: 2.00%) Brazil 1) Meets PA recommendations (3.90%) 2) Meets ST recommendations (20.20%) 3) Meets SD recommendations (61.00%) 4) Number of recommendations met (0: 28.10%; 1: 60.10%; 2: 10.50%; 3: 1.30%) Finland 1) Meets PA recommendations (9.40%) 2) Meets ST recommendations (27.70%) 3) Meets SD recommendations (68.00%) 4) Number of recommendations met (0: 22.70%; 1: 52.50%; 2: 21.90%; 3: 2.90%) Hong Kong 1) Meets PA recommendations (6.30%) 2) Meets ST recommendations (44.80%) 3) Meets SD recommendations (50.00%) 4) Number of recommendations met (0: 27.10%; 1: 44.80%; 2: 28.10%; 3: 0.00%) Mainland China 1) Meets PA recommendations (15.10%) 2) Meets ST recommendations (76.90%) 3) Meets SD recommendations (45.20%) 4) Number of recommendations met 5) (0: 11.80%; 1: 44.60%; 2: 38.20%; 3: 5.40%) Singapore 1) Meets PA recommendations (7.90%) 2) Meets ST recommendations (43.80%) 3) Meets SD recommendations (43.80%) 4) Number of recommendations met (0: 33.70%; 1: 39.30%; 2: 24.70%; 3: 2.20%) South Korea 1) Meets PA recommendations (1.50%) 2) Meets ST recommendations (81.20%) 3) Meets SD recommendations (51.50%) 4) Number of recommendations met 5) (0: 10.4%; 1: 45.00%; 2: 44.60%; 3: 0.00%) United States 1) Meets PA recommendations (5.80%) 2) Meets ST recommendations (32.60%) 3) Meets SD recommendations (55.80%) 4) Number of recommendations met 5) (0: 29.10%; 1: 47.70%; 2: 23.30%; 3: 0.00%)

Table 4 (continued)

Author(s) (year)	Country	Study Design	Participants			Measurement of Movement Behaviours			Main Findings
			Sample Size	Age (years)	Disability Type	PA Measure	ST Measure	SD Measure	
Wang et al. (2022) [64]	United States	Cross-sectional quantitative study	634 Male (70.7%) Female (29.3%)	10–17 (13.76 ± 2.20)	Attention deficit hyperactivity disorder	Parental proxy-reports	Parental proxy-reports	Parental proxy-reports	1) Meets PA recommendations (17.80%) 2) Meets ST recommendations (43.80%) 3) Meets SD recommendations (61.70%) 4) Number of recommendations met 5) (0: 18.10%; 1: 46.80%; 2: 28.50%; 3: 6.50%)
Xu and Qi (2022) [56]	Mainland China	Cross-sectional quantitative study	99 Male (64.65%) Female (35.35%)	7–17 (12.7 ± 2.84)	Autism spectrum disorder	Accelerometer	Parental proxy-reports	Accelerometer	1) Meets PA recommendations (32.30%) 2) Meets ST recommendations (52.50%) 3) Meets SD recommendations (65.70%) 4) Number of recommendations met (0: 13.10%; 1: 39.40%; 2: 31.20%; 3: 16.20%)
Kong et al. (2023) [42]	United States	Cross-sectional quantitative study	956 Male (78.61%) Female (21.39%)	6–17 (11.98 ± 3.81)	Autism spectrum disorder	Parental/caregiver proxy-reports	Parental/caregiver proxy-reports	Parental/caregiver proxy-reports	1) Meets PA recommendations (20.80%) 2) Meets ST recommendations (31.87%) 3) Meets SD recommendations (53.09%) 4) Number of recommendations met (0: 26.97%; 1: 45.34%; 2: 22.65%; 3: 5.04%)
Taylor et al. (2023) [32]	United States	Cross-sectional quantitative study	3470 Male (69.55%) Female (30.45%)	6–17 (11.97 ± 3.48)	Attention deficit hyperactivity disorder	Caregiver proxy-reports	Caregiver proxy-reports	Caregiver proxy-reports	1) Meets PA recommendations (20.01%) 2) Meets ST recommendations (35.24%) 3) Meets SD recommendations (52.64%) 4) Number of recommendations met (0: 27.56%; 1: 42.67%; 2: 24.09%; 3: 5.68%)
Xu and Wang (2023) [57]	Mainland China	Cross-sectional quantitative study	319 Male (62.07%) Female (37.93%)	6–17 (12.93 ± 3.31)	Intellectual disability	Accelerometers	Parental proxy-reports	Accelerometers	1) Meets PA recommendations (33.54%) 2) Meets ST recommendations (54.23%) 3) Meets SD recommendations (75.55%) 4) Number of recommendations met (0: 8.15%; 1: 37.91%; 2: 36.38%; 3: 17.55%)

PA Physical activity, *ST* Screen time, *SD* Sleep duration

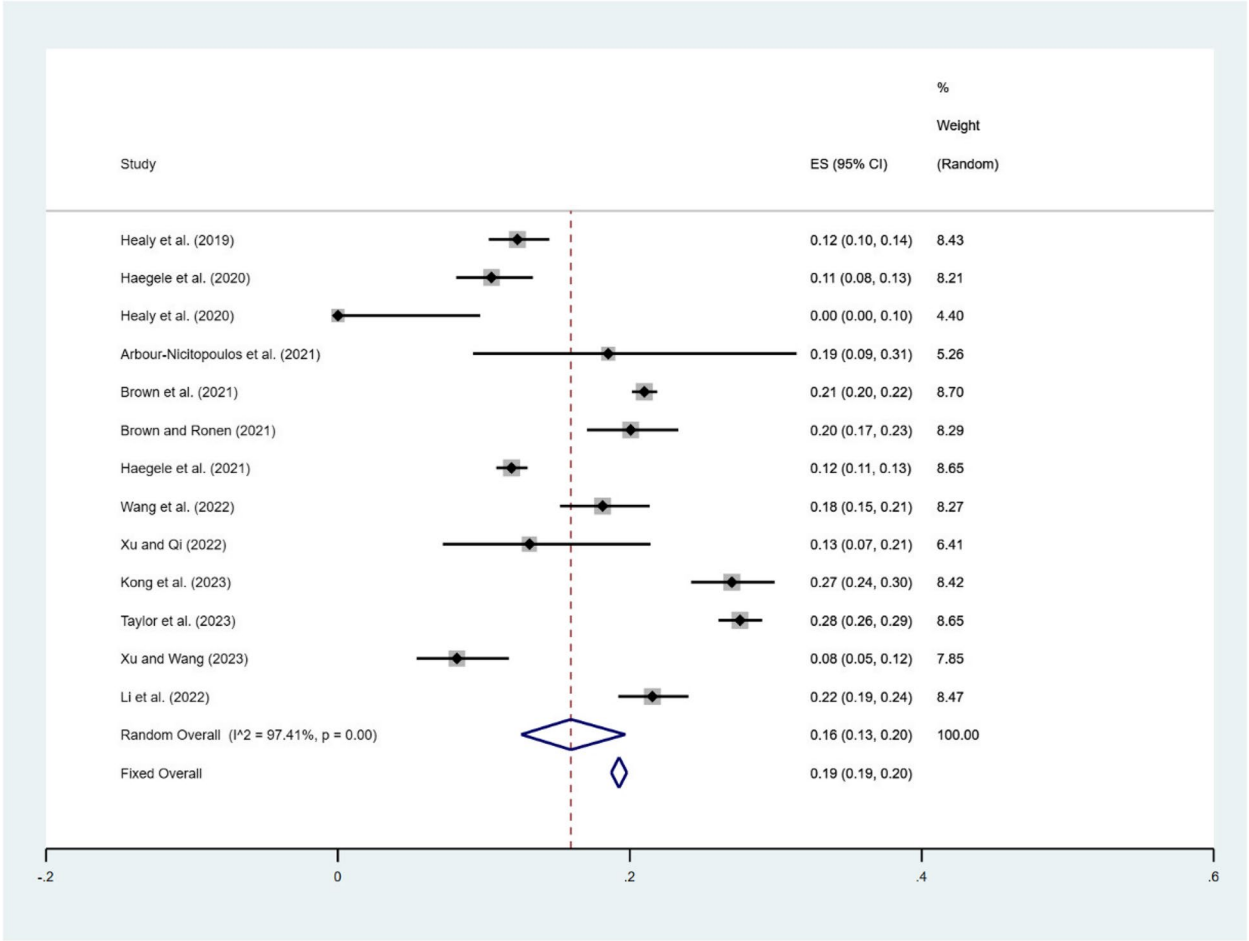

Fig. 2 Forest plot of adherence to none of the three 24-HMG

half of the studies (53.85%). Lastly, the results of most of the studies were reported in sufficient detail (61.54%), and the results supported the conclusions (92.31%).

Characteristics of included studies

Table 4 shows the descriptive characteristics of the 13 included studies. The publication dates ranged from 2019 to 2023. In terms of geographical regions, nine different countries were identified, including four countries (Hongkong, Mainland China, Singapore, and South Korea) in Asia [35, 56, 57], two countries (Finland and Ireland) in Europe [35, 58], two countries (United States and Canada) in North America [32, 34, 35, 42, 59–64] and one country (Brazil) in South America [35]. One study included participants from seven distinct countries [35]. All 13 studies were cross-sectional quantitative studies.

A total of 21,101 participants (65.95% males and 30.05% females) aged 6 to 21 were included in this systematic review and meta-analysis. The most common type of disability was neurodevelopmental disorders, including autism spectrum disorder, cerebral palsy, down syndrome, developmental delay, intellectual disability, learning disability, attention deficit disorder/ attention deficit hyperactivity disorder, epilepsy, tourette syndrome and speech disorder, visual impairments, hearing loss, spinal cord injury, muscular dystrophy, neuromuscular disorder, and amputation.

In terms of measuring the three components of the 24-HMG, PA was assessed using ActiGraph accelerometer measures in 2 of the studies [56, 57], parental/caregiver proxy-reported measures in 10 studies [32, 34, 35, 42, 58, 59, 61–64], and self-reported measures in one study [60]. ST was evaluated through parental/caregiver

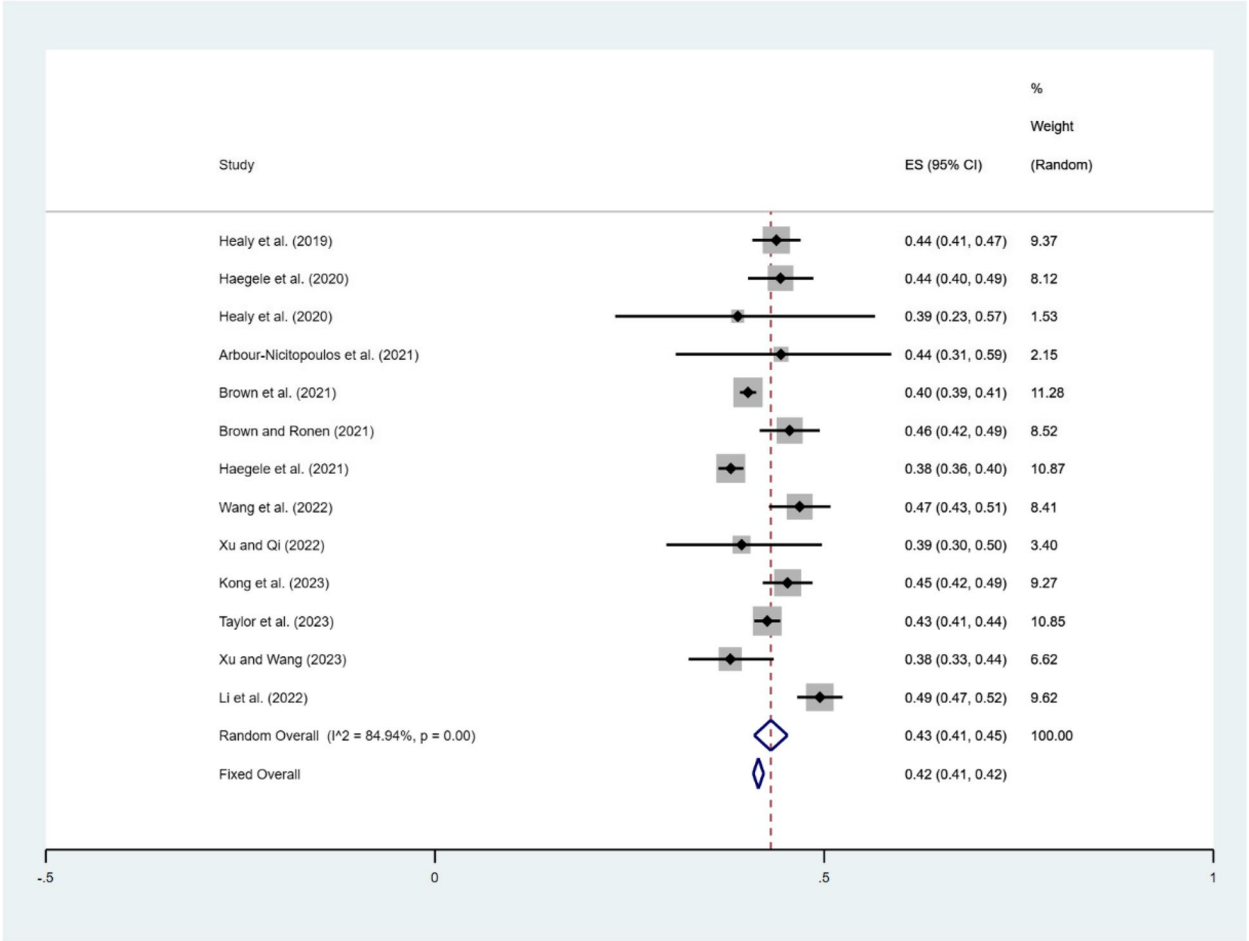

Fig. 3 Forest plot of adherence to one of three 24-HMG

proxy-report in all 13 studies [32, 34, 35, 42, 56–64]. Sleep duration (SD) was obtained by ActiGraph accelerometer measures in 2 studies [56, 57], parental/caregiver proxy-reported measures in 10 studies [32, 34, 35, 42, 58, 59, 61–64], and self-reported measures in one study [60].

Results of syntheses

Level of compliance with the 24-HMG

From the entire sample, Fig. 2 shows that 16% of children and adolescents with disabilities did not meet any of the 24-HMG (95% CI: 0.13–0.20, $p < 0.01$).

As shown in Fig. 3, nearly half (43%) of children and adolescents with disabilities followed to one of three 24-HMG (95% CI: 0.41–0.45, $p < 0.01$).

Approximately one-third (32%) of children and adolescents with disabilities met two out of the three 24-HMG. The specific percentage breakdown is depicted in Fig. 4 (95% CI: 0.28–0.36, $p < 0.01$).

Figure 5 illustrates that the overall compliance with the 24-HMG of children and adolescents with disabilities was 7% (95%CI: 0.05–0.09, $p < 0.01$).

Compliance with individual PA, screen time, and sleep guidelines

Figure 6 shows that only 22% children and adolescents with disabilities attained the recommendations of the PA guidelines (95% CI: 0.18–0.25, $p < 0.01$).

As shown in Fig. 7, close to half of the children and adolescents with disabilities in the whole sample did not meet the ST guidelines. Achievement of the individual guidelines for ST was 49% (95% CI: 0.41–0.56, $p < 0.01$).

As depicted in Fig. 8, irrespective of meeting the other two guidelines, the proportion of the sample that adhered to the individual guidelines for sleep was 59% (95% CI: 0.56–0.61, $p < 0.01$).

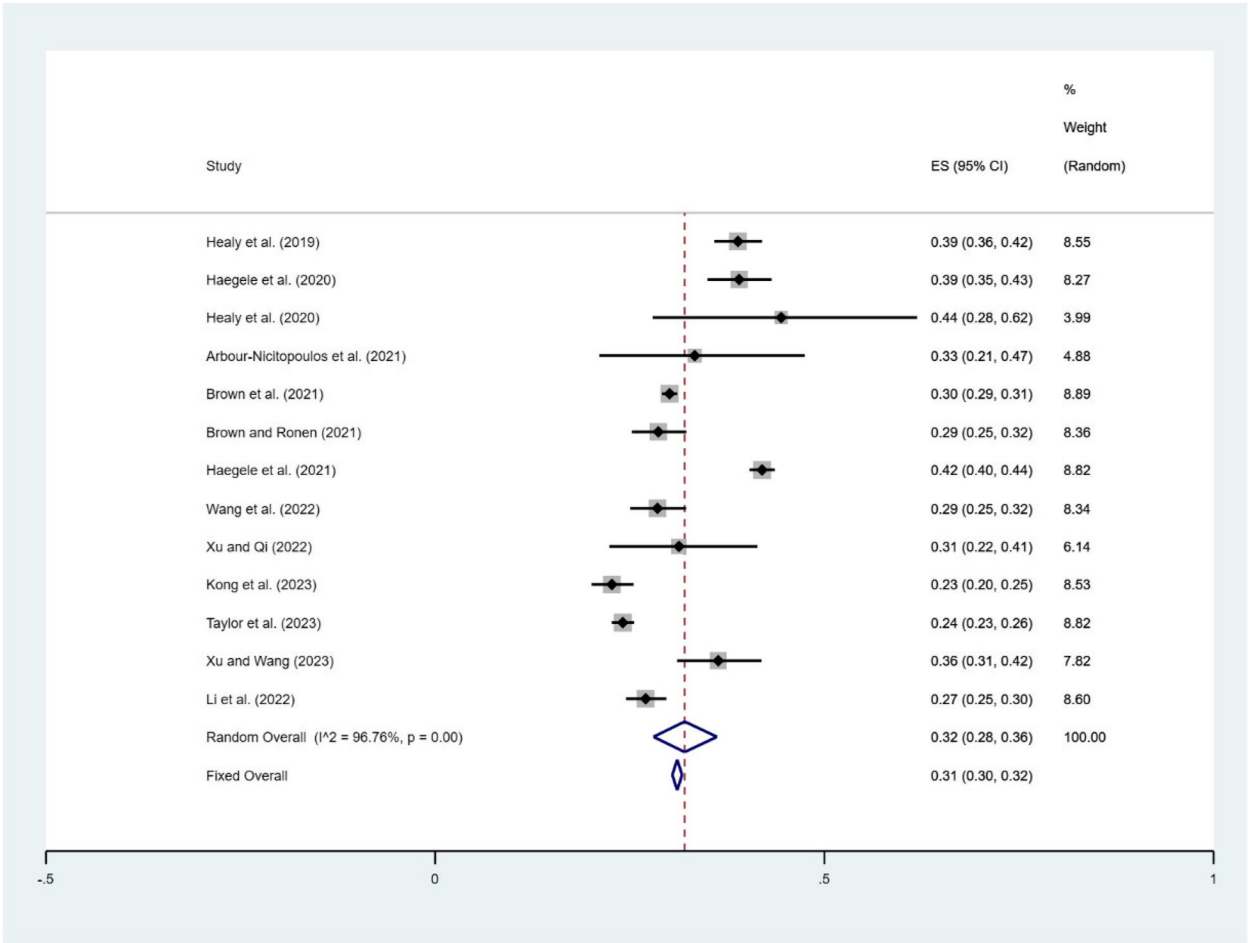

Fig. 4 Forest plot of adherence to two of three 24-HMG

Discussion

To the best of our knowledge, this systematic review and meta-analysis represents the first comprehensive examination of the overall (non) compliance with the 24-HMG among children and adolescents with disabilities, which yielded the following key findings: a total of 7% of 21,101 children and adolescents with disabilities from 9 countries adhered to the overall 24-HMG, while 16% met none of the three recommendations; the highest proportion among them is observed in meeting at least one component of the 24-HMG and nearly 32% met two of three movement guidelines; there are significant differences in adherence to individual movement guidelines, more children and adolescents with disabilities meet recommendations for sleep (59%) than for PA (22%) and ST (49%). Based on these findings, it is evident that children and adolescents with disabilities fall far short of the Canadian 24-HMG for Children and Youth. The data obtained from this systematic review and meta-analysis holds potential value in assisting researchers in related fields to customize interventions that effectively address the specific requirements of this special population.

(Non) compliance with the 24-HMG

Only a very small proportion of children and adolescents with disabilities met all three 24-HMG in the present review, which is consistent with the previous systematic review that reported the overall adherence to the 24-HMG was 7.2% in typically developing children and adolescents aged 6–17 years [39]. Furthermore, our review revealed that approximately one-fifth of children and adolescents with disabilities failed to meet any of the three recommendations. This lack of adherence to all three recommendations is particularly concerning because no single behaviour can compensate for the negative effects of the others [65].

The low overall adherence to the 24-HMG can be attributed to a range of factors among this particular cohort, including physical limitations, cognitive impairments, sensory issues, and social barriers. For

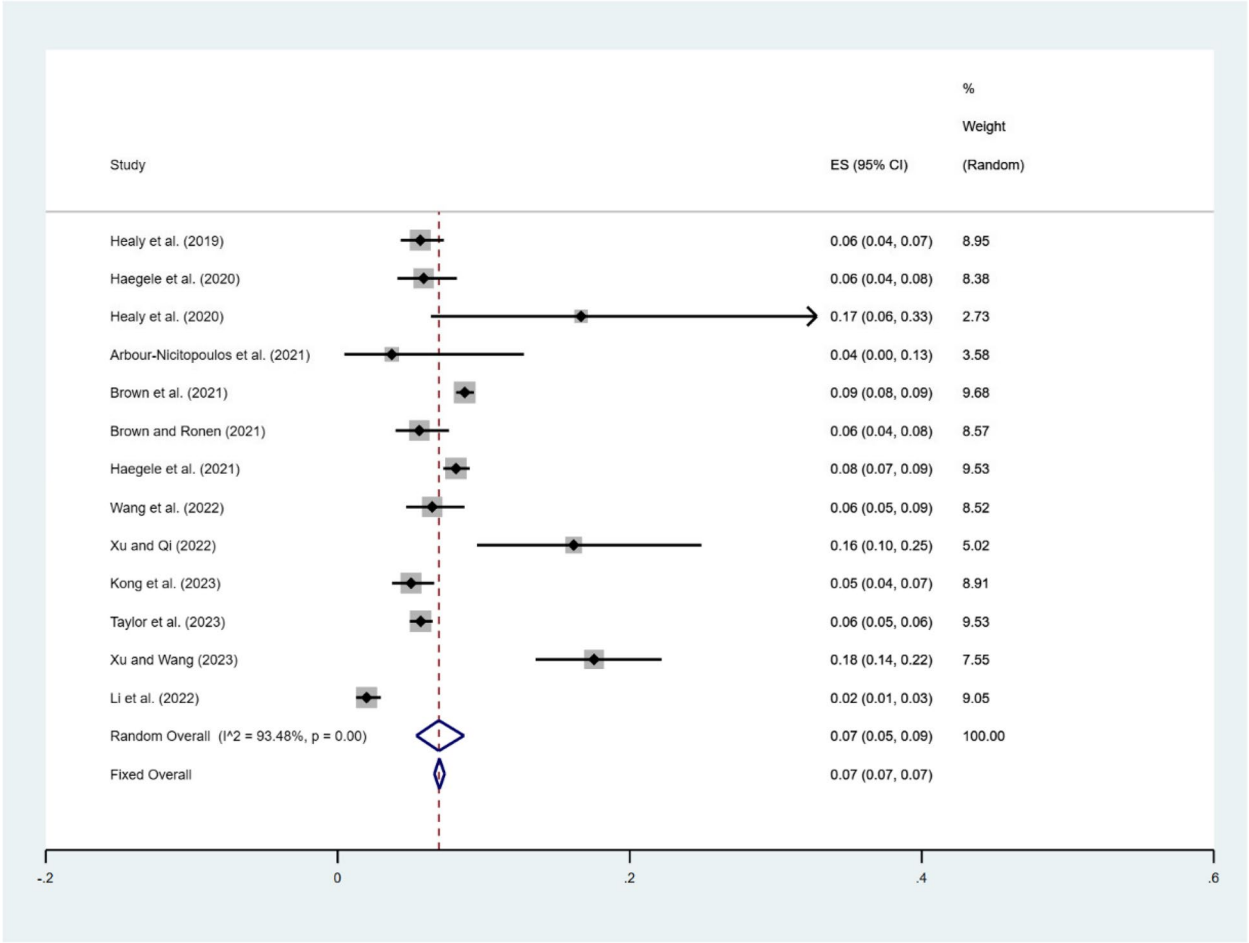

Fig. 5 Forest plot of adherence to all the 24-HMG

example, a study by Stanish et al. [66] suggested that difficulties with motor skills, social interactions, and sensory sensitivities in children with autism spectrum disorder; could contribute to their reduced PA levels. While another study by [67] explored SB in children with cerebral palsy, which revealed that factors such as muscle weakness, spasticity, and mobility limitations hindered their ability to engage in active play and led to increased sedentary time. For sleep quality, a study by Krakowiak et al. [68] investigated sleep difficulties in children with autism spectrum disorders and developmental delays; they found that these children experienced higher rates of sleep problems compared to their typically developing peers. Collectively, these studies demonstrate that children with disabilities encounter unique challenges that can impede their ability to meet the 24-HMG.

It is crucial to acknowledge that children and adolescents who meet the 24-HMG tend to report more favourable health indicators compared to those who do not adhere to the guidelines [69]; while achieving all three guidelines is the ultimate goal, meeting at least one or more is better than meeting none. It should also be noted that children who do not achieve guidelines might face increased risk for health as they transition into adolescence [70]. Multiple meta-analyses have emphasized the favourable relationship between meeting all three 24-HMG throughout the lifespan and psychosocial health indicators when compared with meeting fewer or none of these guidelines [69, 71]. Hence, it is vital to consider the combined influences of these 24-hour movement behaviours and the resulting health implications associated with the duration spent in each behaviour. Such considerations can provide valuable insights for the development of effective interventions and treatments for children and adolescents with disabilities.

Our meta-analysis results revealed that 43% of children and adolescents with disabilities met one guideline, while 32% met two guidelines. When comparing these rates with typically developing children and adolescents,

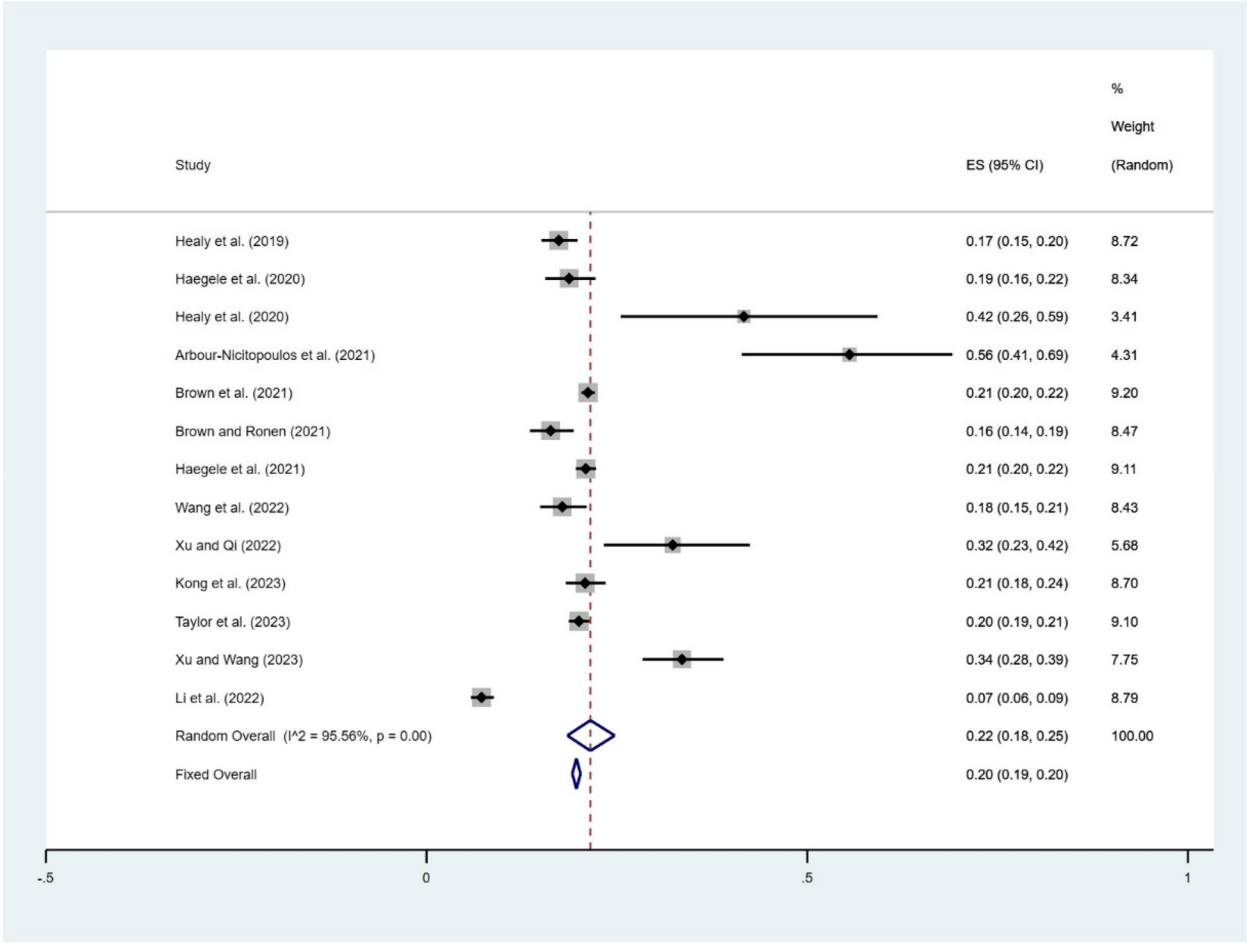

Fig. 6 Forest plot of adherence to PA guidelines

some notable differences emerge. In terms of compliance with one guideline, the rates among the typically developing peers were relatively higher − 51% in Canada [72], 57% in Austria [73], 47.2% in the Czech Republic [74], and 85.8% in China [75]. This indicates that individuals with disabilities generally exhibit lower rates of compliance compared to their counterparts without disabilities in these countries. With regards to compliance with two guidelines, the rates among typically developing peers were as follows: 25% in Canada [72], 23% in Austria [73], 14.2% in the Czech Republic [74], and 8.8% in China [75]. Surprisingly, these figures appear lower than estimates of proportions of children and adolescents with disabilities in our meta-analysis. This tendency can be attributed to their ability to excel in specific combinations that align with their unique abilities and disability type. For instance, individuals with visual impairments typically participate in fewer screen-based activities, leading to their higher compliance rates with the SB recommendation.

It is important to recognize that children and adolescents with disabilities may encounter distinct challenges compared to peers without disabilities, which could hinder their ability to comply with the overall 24-HMG recommendations. Addressing the low compliance rates among children and adolescents with disabilities requires the development of customized strategies and accommodations to overcome the barriers they face and promote adherence to the guidelines [76]. This may involve creating adaptive PA programs to ensure a variety of options that cater to different abilities and preferences of individuals with disabilities [77]. Equally crucial is parental and caregiver involvement, as providing resources, education, and practical tips fosters a supportive environment at home [47]. Improving the accessibility of recreational facilities contributes significantly to creating spaces that encourage and facilitate PA [67]. By implementing these measures collectively, we can create an inclusive and supportive ecosystem that empowers children and adolescents with disabilities to adhere to 24-HMG, thereby

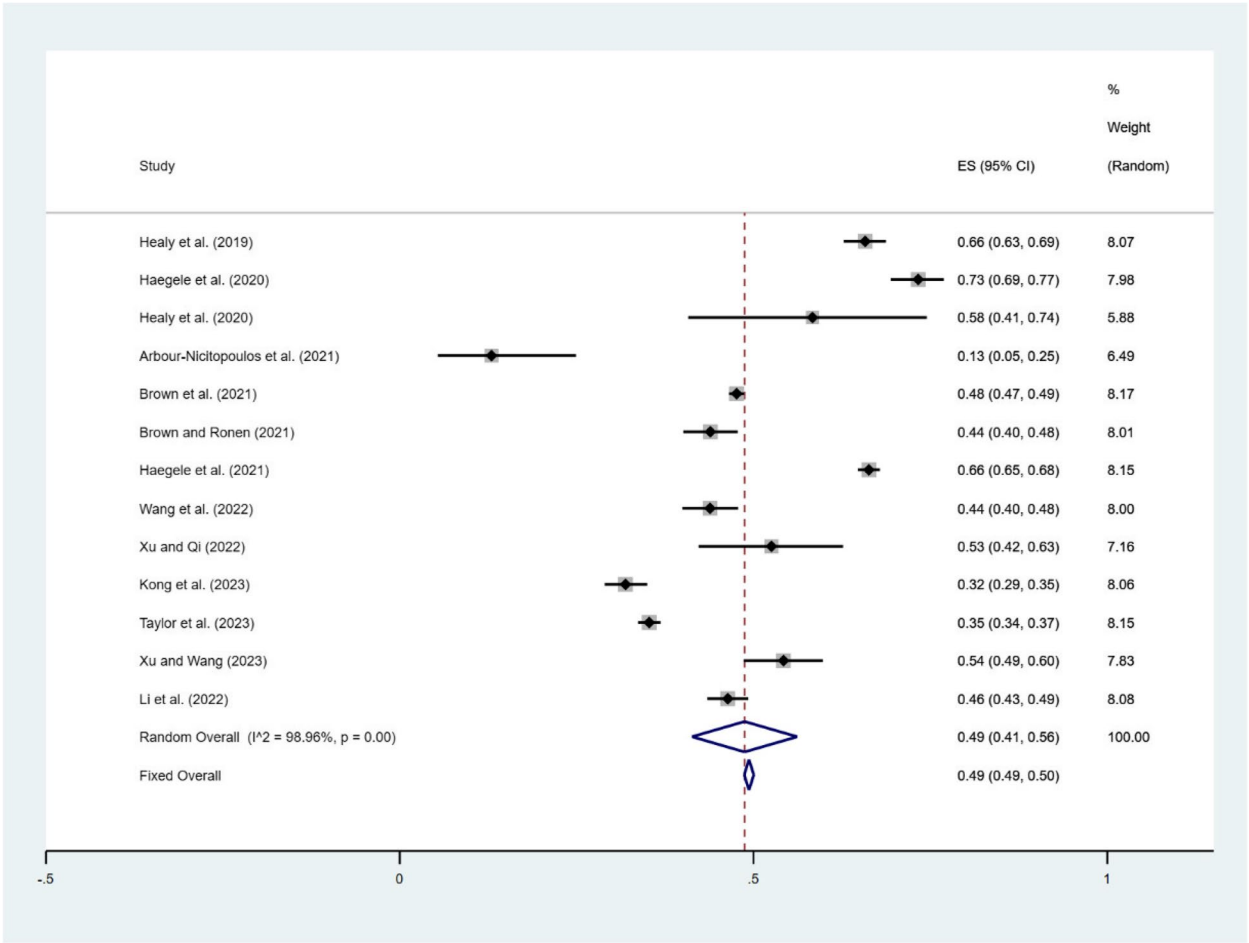

Fig. 7 Forest plot of adherence to ST guidelines

promoting improved overall well-being and positive health outcomes.

Compliance with the individual 24-HMG

Of the three components of the 24-HMG, emphasizing increased adherence to the PA guideline emerges as particularly crucial for children and adolescents with disabilities. This importance is underscored by the fact that only 22% of individuals engage in a sufficient amount of moderate-to-vigorous PA to meet the PA recommendations. Our findings agree with those of the previous study showing that children and adolescents aged 10–17 years with chronic conditions in the United States have the lowest likelihood of meeting the PA guidelines compared to the other 24-HMG [78]. Likewise, existing studies indicate that typically developing children and adolescents are more likely to fall short of meeting PA guidelines when compared to the other components of the 24-HMG [79, 80]. Similar results have been reported in other studies conducted in different populations indicating that PA was identified as the most challenging component of the 24-HMG for all children and adolescents. Specific impairments or functional limitations associated with certain disabilities may directly affect an individual's ability to participate in PA, reducing overall activity levels of children and adolescents with disabilities. Consequently, there is a need for additional research and interventions aimed at overcoming obstacles and promoting PA among children and adolescents with disabilities. This entails emphasizing the development of accommodating surroundings, providing inclusive avenues, and implementing educational initiatives to enhance awareness and motivation for consistent engagement in PA.

Within a 24-hour period, individuals typically engage in one activity behaviour at a time, which means that the allocation of time to one specific activity domain inevitably results in less available time for other activity domains [81]. Consequently, achieving a more active lifestyle involves not only emphasizing the promotion of PA

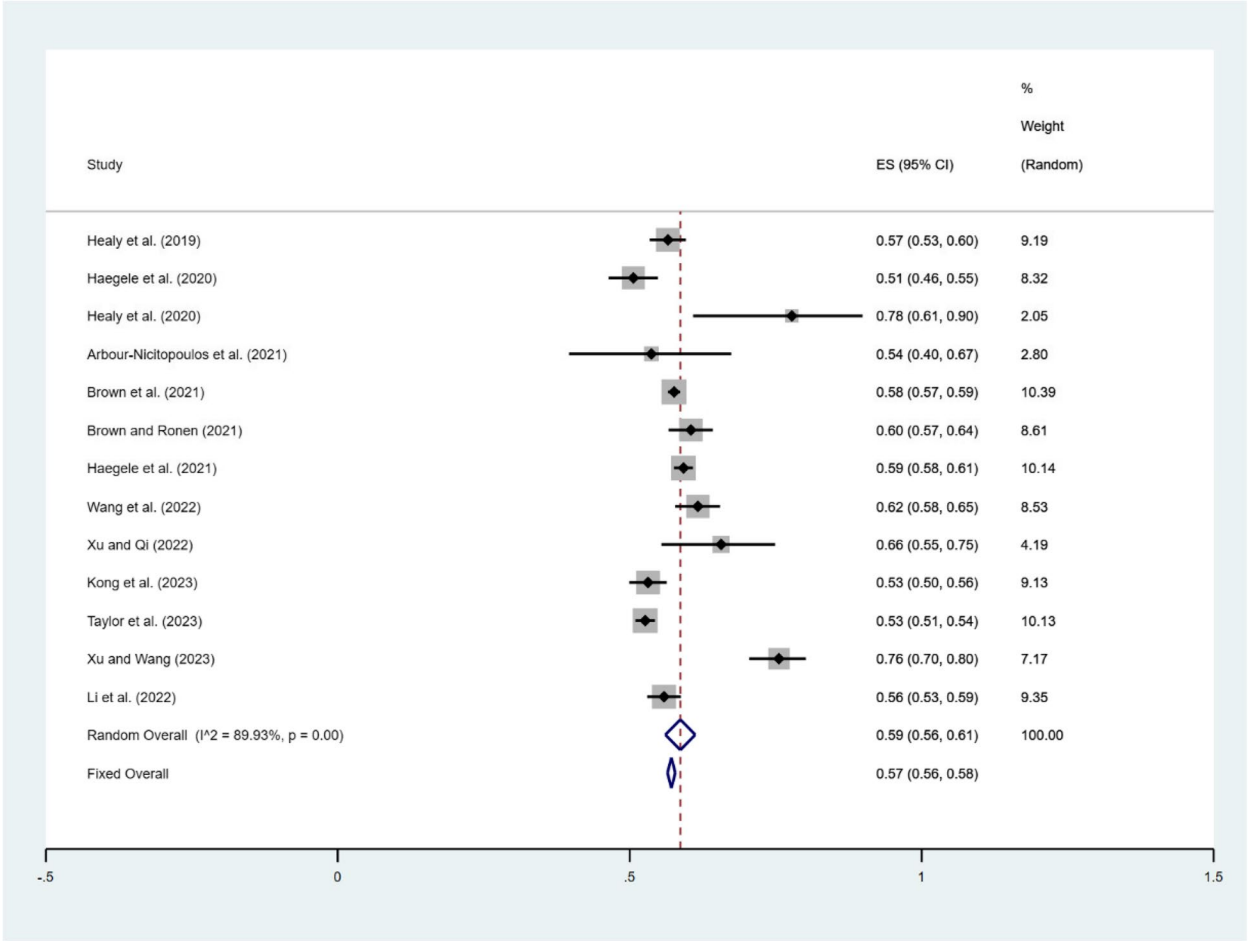

Fig. 8 Forest plot of adherence to sleep guidelines

but also addressing the need to reduce sedentary time. A longitudinal study by Garcia et al. [82] has shown that decreasing the amount of time spent being sedentary can potentially enhance the PA levels of children with autism spectrum disorder on the following day.

Also, exceedingly more than half of the children and adolescents with disabilities had ST that fell outside the recommended range. This figure appears lower than estimates of proportions previously reported in children without chronic conditions aged 10 to 17 years (60%) [78], as well as in typically developing children and adolescents aged 10 to 17 years (range from 62 to 92%) [72, 80, 83]. A possible explanation is that factors such as limited mobility, social isolation, and reduced opportunities of PA for children and adolescents with disabilities may contribute to increased reliance on screens for entertainment and communication [72, 84, 85]. Several studies have indicated that children and adolescents with disabilities tend to have higher ST usage [86, 87]. It is crucial to consider the unique needs and circumstances of each individual when addressing ST usage in this population. Further research and targeted interventions are necessary to promote healthy ST behaviours and find strategies to mitigate excessive screen use among children and adolescents with disabilities.

Furthermore, our findings indicated that children and adolescents with disabilities were more likely to fulfil the age-appropriate sleep recommendations; than meet the guidelines for PA and screen time. The discrepancy could be explained by supportive environment - the home and school environments may prioritize sleep routines and provide structures that facilitate adequate sleep for children with disabilities, since sleep habits may be more easily controlled and managed compared to PA or screen time. Another possible explanation is health related - some disabilities or medical conditions may require children to have sufficient rest and sleep for their overall well-being and management of their condition. Indeed,

this is in line with the results of the previous studies in typically developing children and adolescents and children with chronic health conditions [72, 78, 83]. The impact of sleep on cognitive, behavioural, and emotional development in children with disabilities is crucial; therefore, ideally the child's sleep environment is comfortable, calm, and conducive to sleep. Future research can focus on developing and evaluating effective interventions to improve sleep in children with disabilities. This may involve exploring non-pharmacological approaches such as behavioural interventions, sleep hygiene practices, cognitive-behavioural therapy for insomnia, and assistive technologies. Investigating the efficacy, feasibility, and long-term effects of these interventions is essential for evidence-based practice.

Limitations

When interpreting the findings of this systematic review and meta-analysis, it is important to consider several limitations. Firstly, causal relationships cannot be established due to the reliance on cross-sectional studies. Another limitation is the predominant use of proxy-report measures in the majority of the studies, which may introduce validity and reliability issues with the survey tools. Additionally, both proxy-report and device-based measurements exhibit high variability, which could introduce biasness in the results. Furthermore, the limited availability of data on age (children / adolescents), as well as different disability types hindered subgroup analysis to explore the sources of heterogeneity. This review also focused primarily on reporting the percentage of compliance with 24-hour movement behaviour as the effect size, which may be influenced by context-specific factors. Finally, the presence of high heterogeneity resulting from data limitations also restricted further exploration.

Conclusion

Compliance with the 24-HMG plays a pivotal role in preventing diseases and promoting overall health across all stages of life. The analysis of data from the 13 included studies revealed that children and adolescents with disabilities were less likely to meet the recommended guidelines for PA, screen time, and sleep duration. Furthermore, the majority of them did not fulfil the requirements of all three components outlined in the 24-HMG. These findings strongly emphasize the urgent need to tailor the 24-HMG for children and adolescents with disabilities. Future research should prioritize the development of integrative the 24-HMG specifically designed for the unique needs of this population. Meanwhile, the development of research and intervention programs to foster healthy movement behaviours within this population is crucial. The approach holds the potential to enhance their overall quality of life and promote long-term health outcomes for children and adolescents with disabilities. Given the current evidence, there is a clear need for more global-scaled, device-based data on PA and SD to gain a more comprehensive understanding of overall compliance with the 24-HMG.

Abbreviations

24-HMG	24-hour movement guidelines
PA	Physical activity
SB	Sedentary behaviour
ST	Screen time
SD	Sleep duration

Authors' contributions

Conceptualization: Yaru Hao and Xiaogang Zhou; Data curation: Yaru Hao and Xiaogang Zhou; Formal analysis: Yaru Hao, Xiaogang Zhou and Sanying Peng; Investigation: Yaru Hao and Xiaogang Zhou; Methodology: Yaru Hao, Xiaogang Zhou and Rizal Razman; Project administration: Rizal Razman; Software: Yaru Hao and Xiaogang Zhou; Supervision: Rizal Razman and Nor Shafrin Ahmad; Validation: Yaru Hao and Xiaogang Zhou; Visualization: Yaru Hao; Writing – original draft: Yaru Hao and Xiaogang Zhou; Writing – review & editing: Yaru Hao, Xiaogang Zhou and Rizal Razman. All authors have critically reviewed its content and have approved the final version submitted for publication.

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Availability of data and materials

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

1. Carson V, Hunter S, Kuzik N, Gray CE, Poitras VJ, Chaput J-P, Saunders TJ, Katzmarzyk PT, Okely AD, Connor Gorber S, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update. Appl Physiol Nutr Metab. 2016;41(6):S240–65.
2. Chaput J-P, Gray CE, Poitras VJ, Carson V, Gruber R, Olds T, Weiss SK, Connor Gorber S, Kho ME, Sampson M, 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(6):S266–82.
3. Poitras VJ, Gray CE, Borghese MM, Carson V, Chaput J-P, Janssen I, Katzmarzyk PT, Pate RR, Connor Gorber S, Kho ME, 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):S197–239.
4. Gopinath B, Hardy LL, Kifley A, Baur LA, Mitchell P. Activity behaviors in schoolchildren and subsequent 5-yr change in blood pressure. Med Sci Sports Exerc. 2014;46(4):724–9.
5. Grøntved A, Ried-Larsen M, Møller NC, Kristensen PL, Wedderkopp N, Froberg K, Hu FB, Ekelund U, Andersen LB. Youth screen-time behaviour is associated with cardiovascular risk in young adulthood: the European Youth Heart Study. Eur J Prev Cardiol. 2014;21(1):49–56.
6. Meyer U, Schindler C, Zahner L, Ernst D, Hebestreit H, van Mechelen W, Rocca H-PB-L, Probst-Hensch N, Puder JJ, Kriemler S. Long-term effect of a School-based physical activity program (KISS) on fitness and adiposity in children: a cluster-randomized controlled trial. PLoS ONE. 2014;9(2):e87929.
7. Waldie KE, Thompson JMD, Mia Y, Murphy R, Wall C, Mitchell EA. Risk factors for migraine and tension-type headache in 11 year old children. J Headache Pain. 2014;15(1):60.
8. Carson V, Rinaldi RL, Torrance B, Maximova K, Ball GDC, Majumdar SR, Plotnikoff RC, Veugelers P, Boulé NG, Wozny P, et al. Vigorous physical activity and longitudinal associations with cardiometabolic risk factors in youth. Int J Obes. 2014;38(1):16–21.
9. Toseeb U, Brage S, Corder K, Dunn VJ, Jones PB, Owens M, St Clair MC, van Sluijs EMF, Goodyer IM. Exercise and depressive symptoms in adolescents: a longitudinal cohort study. JAMA Pediatr. 2014;168(12):1093–100.
10. Lin W-H, Yi C-C. Unhealthy sleep practices, Conduct problems, and Daytime Functioning during Adolescence. J Youth Adolesc. 2015;44(2):431–46.
11. Shore SM, Sachs ML, DuCette JP, Libonati JR. Step-count Promotion through a School-based intervention. Clin Nurs Res. 2013;23(4):402–20.
12. Chaput J-P, Carson V, Gray CE, Tremblay MS. Importance of all Movement Behaviors in a 24 Hour Period for Overall Health. Int J Environ Res Public Health. 2014;11(12):12575–81.
13. Tremblay MS, Carson V, Chaput JP, Connor Gorber S, Dinh T, Duggan M, Faulkner G, Gray CE, Gruber R, Janson K, 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):S311–27.
14. Walsh JJ, Barnes JD, Cameron JD, Goldfield GS, Chaput J-P, Gunnell KE, Ledoux A-A, Zemek RL, Tremblay MS. Associations between 24 hour movement behaviours and global cognition in US children: a cross-sectional observational study. Lancet Child Adolesc Health. 2018;2(11):783–91.
15. Australian Government Department of Health and Aged Care. New national 24-hour movement guidelines for 5–17 year olds. Edited by Care AGDoHaA. Canberra, Australia: Australian Government Department of Health and Aged Care; 2019.
16. Ministry of Health. Sit less, move more, sleep well: physical activity guidelines for children and young people. Wellington: Ministry of Health; 2017.
17. Benny Kai Guo L, Anthony David O, Aman P, Muhammad Yazid J. Asia-Pacific Consensus Statement on integrated 24-hour activity guidelines for children and adolescents. Br J Sports Med. 2022;56(10):539.
18. Chen S-T, Liu Y, Tremblay MS, Hong J-T, Tang Y, Cao Z-B, Zhuang J, Zhu Z, Wu X, Wang L, 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.
19. Katzmarzyk PT, Staiano AE. Relationship between meeting 24-Hour Movement guidelines and Cardiometabolic Risk factors in children. J Phys Activity Health. 2017;14(10):779–84.
20. Sampasa-Kanyinga H, Colman I, Goldfield GS, Janssen I, Wang J, Hamilton HA, Chaput J-P. 24-h Movement guidelines and Substance Use among adolescents: a School-based cross-sectional study. Int J Environ Res Public Health. 2021;18(6):3309.
21. Sampasa-Kanyinga H, Colman I, Goldfield GS, Janssen I, Wang J, Tremblay MS, Barnes JD, Walsh JJ, Chaput J-P. 24-Hour Movement behaviors and Internalizing and Externalizing behaviors among Youth. J Adolesc Health. 2021;68(5):969–77.
22. Zeng X, Cai L, Yang W, Tan W, Huang W, Chen Y. Association between the 24-hour movement guidelines and executive function among Chinese children. BMC Public Health. 2022;22(1):1017.
23. Watson A, Dumuid D, Maher C, Olds T. Associations between meeting 24-hour movement guidelines and academic achievement in Australian primary school-aged children. J Sport Health Sci. 2022;11(4):521–9.
24. Xiong X, Dalziel K, Carvalho N, Xu R, Huang L. Association between 24-hour movement behaviors and health-related quality of life in children. Qual Life Res. 2022;31(1):231–40.
25. Services UDoHaH. The Surgeon General's Call to Action 16 to Improve the Health and Wellness of Persons with Disabilities external icon. In. Edited by US Department of Health and Human Services OotSG. Washington, DC; 2005.
26. Organization WH. International Classification of Functioning, Disability and Health (ICF)external icon. In: Edited by Organization WH. Geneva; 2001.
27. Goering S. Rethinking disability: the social model of disability and chronic disease. Curr Rev Musculoskelet Med. 2015;8(2):134–8.
28. Grue J. The social meaning of disability: a reflection on categorisation, stigma and identity. Sociol Health Illn. 2016;38(6):957–64.
29. Rimmer JH, Padalabalanarayanan S, Malone LA, Mehta T. Fitness facilities still lack accessibility for people with disabilities. Disabil Health J. 2017;10(2):214–21.
30. Deal M. Aversive disablism: subtle prejudice toward disabled people. Disabil Soc. 2007;22(1):93–107.
31. Cologon K. What is disability? It depends whose shoes you are wearing: parent understandings of the concept of disability. Disabil Stud Q. 2016;36(1). https://doi.org/10.18061/dsq.v36i1.4448.
32. Taylor A, Kong C, Zhang Z, Herold F, Ludyga S, Healy S, Gerber M, Cheval B, Pontifex M, Kramer AF, et al. Associations of meeting 24-h movement behavior guidelines with cognitive difficulty and social relationships in children and adolescents with attention deficit/hyperactive disorder. Child Adolesc Psychiatry Mental Health. 2023;17(1):42.
33. Wang W, Haegele JA, Wu Y, Li C. Meeting the 24-Hour Movement guidelines and outcomes in adolescents with ADHD: a cross-sectional observational study. Int J Environ Res Public Health. 2022;19(4):2132.
34. Healy S, Aigner CJ, Haegele JA, Patterson F. Meeting the 24-hr movement guidelines: an update on US youth with autism spectrum disorder from the 2016 National Survey of children's Health. Autism Res. 2019;12(6):941–51.
35. Li C, Haegele JA, Sun F, Alves MLT, Ang SHC, Lee J, Ng K, dos Santos Alves I, Healy S, Huang WY, et al. Meeting the 24-h movement guidelines and health-related outcomes among youth with autism spectrum disorder: a seven-country observational study. Child Adolesc Psychiatry Mental Health. 2022;16(1):50.
36. Lu Y, Zhao M. Adherence to 24-h movement guidelines and cognitive difficulties in adolescents. Complement Ther Clin Pract. 2023;51:101744.
37. Pan N, Lin L-Z, Nassis GP, Wang X, Ou X-X, Cai L, Jing J, Feng Q, Dong G-H, Li X-H. Adherence to 24-hour movement guidelines in children with mental, behavioral, and developmental disorders: data from the 2016–2020 National Survey of children's Health. J Sport Health Sci. 2023;12(3):304–11.
38. Huang S, Huang Y, Gu Y, Chen H, Lv R, Wu S, Song P, Zhao D, Hu L, Yuan C. Adherence to 24-Hour Movement guidelines in Relation to the risk of overweight and obesity among children and adolescents. J Adolesc Health. 2023;73(5):887–95.
39. 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 pre-school to adolescence: a systematic review and meta-analysis including 387,437 participants and 23 countries. J Sport Health Sci. 2022;11(4):427–37.
40. Vanderloo LM, Taylor L, Yates J, Bassett-Gunter R, Stanley M, Tucker P. Physical activity among young children with disabilities: a systematic review protocol. BMJ Open. 2022;12(8):e060140.
41. Xu WH, Qi J. Meeting 24-hour movement guidelines: their relationships with overweight and obesity among Chinese children with autism spectrum disorder. RESEARCH IN AUTISM SPECTRUM DISORDERS; 2022. p. 99.
42. Kong C, Chen A, Ludyga S, Herold F, Healy S, Zhao M, Taylor A, Müller NG, Kramer AF, Chen S, et al. Associations between meeting 24-hour movement guidelines and quality of life among children and adolescents with autism spectrum disorder. J Sport Health Sci. 2023;12(1):73–86.

43. Porter CD, McPhee PG, Kwan MY, Timmons BW, Brown DMY. 24-hour movement guideline adherence and mental health: a cross-sectional study of emerging adults with chronic health conditions and disabilities. Disabil Health J. 2023;16(3):101476.
44. Healy S, Brewer B, Garcia J, Daly J, Patterson F. Sweat, sit, Sleep: a compositional analysis of 24-hr Movement behaviors and Body Mass Index among children with Autism Spectrum Disorder. Autism Research: Official J Int Soc Autism Res. 2021;14(3):545–50.
45. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Int J Surg. 2021;88:105906.
46. Amir-Behghadami M, Janati A. Population, intervention, comparison, outcomes and study (PICOS) design as a framework to formulate eligibility criteria in systematic reviews. Emerg Med J. 2020;37(6):387–289.
47. Hao Y, Razman R. Family factors associated with physical activity in children with intellectual disability: a systematic review. J Intellect Disabil. 2022;13:17446295221130913.
48. Kharel M, Sakamoto JL, Carandang RR, Ulambayar S, Shibanuma A, Yarotskaya E, Basargina M, Jimba M. Impact of COVID-19 pandemic lockdown on movement behaviours of children and adolescents: a systematic review. BMJ Global Health. 2022;7(1):e007190.
49. Ku B, Rhodes RE. Physical activity behaviors in parents of children with disabilities: a systematic review. Res Dev Disabil. 2020;107:103787.
50. Ku B, Sung M-C. Physical activity among parents of Children with disabilities: a systematic review. J Fam Issues. 2021;43(8):2134–58.
51. Yang W, Liang X, Sit CH-P. Physical activity and mental health in children and adolescents with intellectual disabilities: a meta-analysis using the RE-AIM framework. Int J Behav Nutr Phys Activity. 2022;19(1):80.
52. Kmet LM, Cook LS, Lee RC. Standard quality assessment criteria for evaluating primary research papers from a variety of fields. Alberta Heritage Foundation for Medical Research Edmonton; 2004.
53. Eddens L, van Someren K, Howatson G. The role of intra-session exercise sequence in the interference effect: a systematic review with meta-analysis. Sports Medicine. 2018;48:177–188.
54. Higgins JP, Green S. Cochrane handbook for systematic reviews of interventions. London, UK.: The Cochrane Collaboration; 2011.
55. Barker TH, Migliavaca CB, Stein C, Colpani V, Falavigna M, Aromataris E, Munn Z. Conducting proportional meta-analysis in different types of systematic reviews: a guide for synthesisers of evidence. BMC Med Res Methodol. 2021;21(1):189.
56. Xu WH, Qi J. Meeting 24-hour movement guidelines: their relationships with overweight and obesity among Chinese children with autism spectrum disorder. Res Autism Spectr Disorders. 2022;99:102066.
57. Xu WH, Wang LJ. Adherence to 24-h movement guidelines among Chinese children and adolescents with intellectual disabilities. J Intellect Disabil Res. 2023;67(7):668–78.
58. Healy S, Patterson F, Williams E, Lozano AJ, Hanlon AL, Obrusnikova I. Rethinking daily movement behaviours of children with autism spectrum disorder: meeting the 24-hour movement guidelines. Eur J Adapt Adapt Phys. 2020;13(8). https://doi.org/10.5507/euj.2020.006.
59. Haegele JA, Zhu X, Healy S, Patterson F. Proportions of youth with visual impairments meeting 24-hr movement guidelines. Child Care Health Dev. 2020;46(3):345–51.
60. Arbour-Nicitopoulos KP, Bassett-Gunter RL, Leo J, Sharma R, Olds T, Latimer-Cheung AE, Martin Ginis KA. A cross-sectional examination of the 24-hour movement behaviours in Canadian youth with physical and sensory disabilities. Disabil Health J. 2021;14(1):100980.
61. Brown DMY, McPhee PG, Kwan MY, Timmons BW. Implications of disability severity on 24-Hour Movement Guideline Adherence among Children with Neurodevelopmental disorders in the United States. J Phys Activity Health. 2021;18(11):1325–31.
62. Brown DMY, Ronen GM. Associations between 24-hour movement guideline adherence and mental health disorders among young people with active and inactive epilepsy. Epilepsy Behav. 2021;125:108386.
63. Haegele JA, Zhu X, Healy S, Patterson F. The 24-Hour Movement guidelines and Body Composition among Youth receiving Special Education Services in the United States. J Phys Activity Health. 2021;18(7):838–43.
64. Wang W, Haegele JA, Wu Y, Li C. Meeting the 24-Hour Movement guidelines and outcomes in adolescents with ADHD: a cross-sectional observational study. Int J Environ Res Public Health. 2022;19(4):2132.
65. Ulf E, Jakob T, Morten WF, Jostein Steene J, Bjørge HH, Barbara JJ, Peter HW, Keith MD, Steven H, Virginia JH, 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(24):1499.
66. Stanish HI, Curtin C, Must A, Phillips S, Maslin M, Bandini LG. Physical activity levels, frequency, and type among adolescents with and without Autism Spectrum Disorder. J Autism Dev Disord. 2017;47(3):785–94.
67. Nora S, Anneliese Jane S, Megan B. Perceived barriers and facilitators to physical activity for children with disability: a systematic review. Br J Sports Med. 2012;46(14):989.
68. Krakowiak P, Goodlin-Jones B, Hertz-Picciotto I, Croen LA, Hansen RL. Sleep problems in children with autism spectrum disorders, developmental delays, and typical development: a population-based study. J Sleep Res. 2008;17(2):197–206.
69. 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(6):493–510.
70. Sampasa-Kanyinga H, Colman I, Goldfield GS, Janssen I, Wang J, Podinic I, Tremblay MS, Saunders TJ, Sampson M, Chaput J-P. 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 Activity. 2020;17(1):72.
71. Feng J, Zheng C, Sit CH-P, Reilly JJ, Huang WY. Associations between meeting 24-hour movement guidelines and health in the early years: a systematic review and meta-analysis. J Sports Sci. 2021;39(22):2545–57.
72. Janssen I, Roberts KC, Thompson W. Adherence to the 24-Hour Movement guidelines among 10- to 17-year-old canadians. Health Promotion Chronic Disease Prev Canada: Res Policy Pract. 2017;37(11):369–75.
73. Khan A, Lee E-Y, Tremblay MS. Meeting 24-h movement guidelines and associations with health related quality of life of Australian adolescents. J Sci Med Sport. 2021;24(5):468–73.
74. Rubín L, Gába A, Dygrýn J, Jakubec L, Materová E, Vencálek O. Prevalence and correlates of adherence to the combined movement guidelines among Czech children and adolescents. BMC Public Health. 2020;20(1):1692.
75. Ying L, Zhu X, Haegele J, Wen Y. Movement in High School: proportion of Chinese adolescents meeting 24-Hour Movement guidelines. Int J Environ Res Public Health. 2020;17(7):2395.
76. Bassett-Gunter R, Tomasone J, Latimer-Cheung A, Arbour-Nicitopoulos K, Disimino K, Larocca V, Tristani L, Ginis KM, Leo J, Vanderloo L, et al. Evidence-informed recommendations for community-based organizations developing physical activity information targeting families of children and Youth with disabilities. ADAPTED PHYSICAL ACTIVITY QUARTERLY; 2023.
77. Love A, Agiovlasitis S. How do adults with Down Syndrome Perceive Physical Activity? Adapted Phys Activity Q. 2016;33(3):253–70.
78. Healy S, Foley J, Haegele JA. Physical activity, screen time, and Sleep Duration among Youth with Chronic Health conditions in the United States. Am J Health Promotion. 2020;34(5):505–11.
79. Shi Y, Huang WY, Sit CH-P, Wong SH-S. Compliance with 24-Hour Movement guidelines in Hong Kong adolescents: associations with Weight Status. J Phys Activity Health. 2020;17(3):287–92.
80. Yang Y, Yuan S, Liu Q, Li F, Dong Y, Dong B, Zou Z, Ma J, Baker JS, Li X, 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(14):2822.
81. Verschuren O, Hulst RY, Voorman J, Pillen S, Luitwieler N, Dudink J, Gorter JW. 24-hour activity for children with cerebral palsy: a clinical practice guide. Dev Med Child Neurol. 2021;63(1):54–9.
82. Garcia J, Brewer B, Healy S, Patterson F. The temporal relationships between 24-h Movement behaviors among children with Autism Spectrum Disorder. Adv Neurodevelopmental Disorders. 2022;6(2):157–65.
83. Tapia-Serrano MA, Sevil-Serrano J, Sánchez-Miguel PA. Adherence to 24-Hour Movement guidelines among Spanish adolescents: differences between boys and girls. Children. 2021;8(2):95.
84. Healy S, Garcia JM. Psychosocial correlates of physical activity participation and screen-time in typically developing children and children on the Autism Spectrum. J Dev Phys Disabil. 2019;31(3):313–28.
85. Healy S, Garcia JM, Haegele JA. Environmental Factors Associated with physical activity and screen time among children with and without Autism Spectrum Disorder. J Autism Dev Disord. 2020;50(5):1572–9.

86. Hutzler Y, Tesler R, Ng K, Barak S, Kazula H, Harel-Fisch Y. Physical activity, sedentary screen time and bullying behaviors: exploring differences between adolescents with and without disabilities. Int J Adolescence Youth. 2021;26(1):110–26.
87. Ng KW, Augustine L, Inchley J. Comparisons in screen-time behaviours among adolescents with and without long-term illnesses or disabilities: results from 2013/14 HBSC Study. Int J Environ Res Public Health. 2018;15(10):2276.

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