Review

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

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Abstract

Background: Meeting the 24-Hour Movement Guidelines (physical activity, screen time, and sleep duration) has been associated with positive health indicators. However, there are no previous meta-analyses that have examined the overall adherence to the 24-Hour Movement Guidelines from pre-school to adolescence across the world. Therefore, the main purpose of this systematic review and meta-analysis was to examine the overall (non)adherence to the 24-Hour Movement Guidelines among preschoolers, children, and adolescents worldwide.

Methods: Four electronic databases (MEDLINE, Scopus, Web of Science, and Cochrane Database of Systematic Reviews) were searched for quantitative studies published in Spanish and English between January 2016 and May 2021. Studies that were conducted with apparently healthy participants and reported the overall (non)adherence to the 24-Hour Movement Guidelines in preschoolers and/or children and/or adolescents were included.

Results: Sixty-three studies comprising 387,437 individuals (51% girls) aged 3−18 years from 23 countries were included. Overall, 7.12% (95% confidence interval (95%CI): 6.45%−7.78%) of youth met all three 24-Hour Movement Guidelines, and 19.21% (95%CI: 16.73%−21.69%) met none of the 3 recommendations. Concerning sex, adherence to all recommendations was significantly lower in girls (3.75%, 95%CI: 3.23%−4.27%) than in boys (6.89%, 95%CI: 5.89%−7.89%) ($p < 0.001$). However, there were no sex differences regarding adherence to any of the 3 individual recommendations (girls, 15.66%, 95%CI: 8.40%−22.92%; boys, 12.95%, 95%CI: 6.57%−19.33%). In terms of age group, adherence to the 3 recommendations was 11.26% (95%CI: 8.68%−13.84%), 10.31% (95%CI: 7.49%−13.12%), and 2.68% (95%CI: 1.78%−3.58%) in preschoolers, children, and adolescents, respectively. Conversely, 8.81% (95%CI: 5.97%−11.64%) of preschoolers, 15.57% (95%CI: 11.60%−19.54%) of children, and 28.59% (95%CI: 22.42%−34.75%) of adolescents did not meet any of the recommendations. South America was the region with the lowest adherence (all: 2.93%; none: 31.72%). Overall adherence to the 24-Hour Movement Guidelines was positively related to country Human Development Index ($\beta = -0.37$, 95%CI: -0.65 to -0.09; $p = 0.010$).

Conclusion: Most young people fail to meet the three 24-Hour Movement Guidelines, particularly adolescents, girls, and those who are from countries with a lower Human Development Index. Moreover, 1 in 5 young people did not meet any of these recommendations. Therefore, these results highlight the need to develop age- and sex-specific strategies to promote these movement behaviors from the early stages of life.

Keywords: Exercise; Lifestyle; Movement behaviors; Sedentary behaviors; Youth

1. Introduction

It is well documented that high levels of physical activity,[1] low levels of screen time,[2] and an optimal sleep duration[3] are independently associated with positive health benefits in preschoolers, children, and adolescents. However, these 3 behaviors are co-dependent because they are distributed across the whole day (24-h period) and should therefore be considered simultaneously. Considering the importance of an optimal time allocation during the whole day for overall health, the Canadian 24-Hour Movement Guidelines for Children and Youth (aged 5−17 years)[4] and preschoolers (aged 3−4 years)[5] were developed and released in 2016 and 2017, respectively. Soon after, these 24-Hour Movement Guidelines were also adopted by Australia (5−17 years old), South Africa (school-aged children), New Zealand (5−17 years old), and the Asia-Pacific region.[6] According to these guidelines, within a 24-h period, preschoolers should accumulate at least 180 min of physical activity (of which, at least 60 min should be moderate-to-vigorous physical activity), ≤1 h/day of recreational screen time, and 10−13 h of sleep.[4] Children and adolescents should accumulate at least 60 min per day of moderate-to-vigorous physical activity, ≤2 h/day of recreational screen time, and 9−11 h of sleep per day (5−13 years old) or 8−10 h of sleep per day (14−17 years old).[4]

Meeting all three 24-Hour Movement Guidelines has been associated in preschoolers, children, and adolescents with physical (e.g., adiposity, physical fitness), psychosocial (e.g., well-being, health-related quality of life), and cognitive benefits (e.g., academic performance, global cognition) as compared with meeting fewer or none of these recommendations.[7] A 2020 systematic review that examined the associations between meeting the 24-Hour Movement Guidelines and multiple health indicators from childhood through to older adulthood also showed that only between 5% and 24% of preschoolers, 4.8% and 10.8% of children, and 1.6% and 9.7% of adolescents met all 3 components of the 24-Hour Movement Guidelines in the 31 identified studies.[7] Nonetheless, this review did not perform a meta-analysis to examine overall adherence to the 24-Hour Movement Guidelines from preschool to adolescence. The review also did not examine the proportion of young people who did not meet any of the 3 behavior recommendations of the 24-Hour Movement Guidelines.[7] This analysis should also be carried out because there may be studies with a high percentage of participants who meet the overall 24-Hour Movement Guidelines and, at the same time, a high percentage of preschoolers, children, and adolescents who do not meet any of the 3 recommendations. Previous studies have shown that between 0.01% and 33.0% of preschoolers,[8] 0.8%[9] and 30.5%[10] of children, and 4.7%[11] and 60.0%[12] of adolescents did not meet any of the three 24-Hour Movement Guidelines. The high number of young people not meeting any of the 3 recommendations is a public health concern because of the associated negative consequences on adiposity, fitness, and cardiometabolic, mental, social, cognitive, and emotional health.[7] Determining adherence to the 24-Hour Movement Guidelines worldwide in young people is important as it may provides new evidence for policy makers, health practitioners, and other stakeholders to target and increase health promotion efforts through health education, screening, and early intervention.[4] This could also encourage other countries to adopt these 24-Hour Movement Guidelines in their health policies.

To date, no meta-analysis has examined adherence to the 24-Hour Movement Guidelines, and whether geographical location, country Human Development Index (HDI), age group, and/or sex moderate this adherence. The above-mentioned systematic review published by Rollo et al.[7] showed lower compliance with the 24-Hour Movement Guidelines in adolescents and girls. Moreover, previous studies conducted in 49 countries have suggested that higher HDI is related to lower physical activity levels and higher sedentary behaviors within the population of a given country.[13] However, no differences in sleep duration related to country HDI have been found.[14] In addition, there seem to be differences in physical activity, sedentary behaviors, and sleep duration depending on the geographical area.[13,14] Therefore, a more fine-grained picture of the overall adherence to the 24-Hour Movement Guidelines according to these sociodemographic variables is required to adapt interventions to these different target groups. To fill these gaps in the scientific literature, the present systematic review and meta-analysis aimed to (a) evaluate adherence to the overall 24-Hour Movement Guidelines for preschoolers (3−4 years), children (5−11 years), and adolescents (12−18 years) across the world; (b) examine the proportion of preschoolers, children, and adolescents who do not meet any of the 3 recommended behaviors of the 24-Hour Movement Guidelines; and (c) investigate the moderating associations of geographic location, country HDI, age group, and sex on these adherence rates.

2. Methods

This systematic review and meta-analysis was registered in the International Prospective Register of Systematic Reviews (PROSPERO) (Registration number: CRD42021229529) and conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement published in 2021.[15]

2.1. Eligibility criteria

Studies were required to meet the following criteria related to Participants, Intervention, Comparison, Outcomes, and Study:[16,17] (a) participants: apparently healthy preschoolers, children, and adolescents aged 3 to 18 years; (b) outcome: meeting the overall 24-Hour Movement Guidelines and/or none of the individual movement behavior recommendations; (c) study design: no restriction, except for systematic reviews and/or meta-analysis, qualitative and case studies. Searching was restricted to articles in published in English- and Spanish-language peer-reviewed journals.

The exclusion criteria included: (a) studies conducted exclusively with young people who are overweight or obese,

or who have a diagnosis of physical or mental disorders; (b) intervention studies conducted exclusively with non-active individuals at baseline; (c) studies that were published before 2016[4] because the first 24-Hour Movement Guidelines for children and youth were released in 2016;[4] (d) studies conducted with adults, older people, infants, toddlers, and/or babies; (e) studies in which data were collected during coronavirus disease-2019 (COVID-19) because they could introduce bias; (f) studies based on data from the same surveys/studies to avoid duplication; (g) gray literature (e.g., protocol studies, systematic reviews and/or meta-analysis, editorials, and abstracts or congress communications); and (h) qualitative and case studies.

2.2. Information sources and search strategy

Two researchers (MATS and JSS) systematically searched PubMed, Scopus, Web of Science, and Cochrane Database of Systematic Reviews databases, with date limits from June 16th, 2016 to May 20th, 2021. Based on the Participants, Intervention, Comparison, Outcomes, and Study criteria, studies were identified using all possible combinations of the following groups of search terms: (a) "early*" OR "preschool*" OR "child*" OR "adolesc*" OR "young*" OR "youth" OR "student*" OR "teena*"; (b) "movement behavio*" OR "24-h*"; (c) "physical activity" OR "screen" OR "sleep*"; (d) "guidelines" OR "recommendations". The search terms were adapted for each database in combination with database-specific filters. The complete research strategy is provided in Supplementary Table 1. In addition, the list of references of the studies included in this review and in a previous systematic review[7] was thoroughly reviewed to ensure that no eligible studies were missed.

2.3. Selection process

After identifying eligible studies, Mendeley (Version for Windows 10; Elsevier, Amsterdam, Netherlands) was used to remove duplicate studies. Two members of the research team (MATS and JSS) conducted the selection process independently and screened every title and abstract to identify potentially relevant articles to be reviewed in the full-text phase. A third researcher (PASM) participated to resolve any discrepancies.

2.4. Data collection process

Two researchers (MATS and JSS) independently reviewed the full text of selected studies. One researcher extracted the information from the selected articles (MATS), and another (JSS) checked the data for accuracy. The following information was extracted from the studies that met the selection criteria (Supplementary Table 2): author(s), year of publication, country or countries, sample size, age range, study design, and method of measurement of physical activity, screen time, and sleep duration. When a study had both self-reported and device-based measures, the device-based measures were chosen. In studies with several measurement times (e.g., longitudinal, intervention studies), the information and data of the 1st measurement time (i.e., baseline) was considered.

2.5. Data items

The proportion of participants meeting all 3 recommendations of the 24-Hour Movement Guidelines, meeting 1 or some of the individual components separately, and meeting none of them were extracted by one researcher (MATS). Another researcher (JSS) checked the data for accuracy. In case of a discrepancy between these 2 researchers, a third researcher (AGH) reviewed the information.

Supplementary Table 2 of standardized data items was organized according to age group (i.e., preschoolers, children, adolescents, and youth (studies that included both children and adolescents)) and sex.

2.6. Risk of bias assessment

Information on the authors, affiliations, date, and source of each study included in this review was hidden to avoid bias in the assessment of the methodological quality of the articles. Two researchers (PASM and MATS) independently assessed the methodological quality of the included studies (i.e., high quality, medium quality, and low quality). Discrepancies were resolved by a third researcher (AGH). The methodological quality of studies was assessed using the Quality Assessment Tool for Observational Cohort and Cross-sectional Studies.[18] This checklist was comprised of 14 items for longitudinal studies, of which 11 could be applied to observational and cross-sectional studies (except Items 7, 10, and 13). This tool consists of 14 items that measure the following elements: (a) research question; (b and c) study population; (d) groups recruited from the same population and uniform eligibility criteria; (e) sample size justification; (f) exposure assessed prior to outcome measurement; (g) sufficient timeframe to see an effect; (h) different levels of the exposure of interest; (i) exposure measures and assessment; (j) repeated exposure assessment; (k) outcome measures; (l) blinding of outcome assessors; (m) follow-up rate; and (n) statistical analyses. The complete list of quality assessment questions has been included in the footer of Supplementary Table 3. Each item was classified as yes (1 point), no (0 points), not reported or not applicable and was rated with 1 point if the article provided a sufficient description of the item or with 0 points if the publication did not provide an adequate description or did not address and/or include the quality criteria of the item. Furthermore, it was considered not reported if an insufficient or unclear description of the item was provided, while not applicable was assigned in cases where the criteria to be assessed could not be applied. The maximum possible score that could be achieved was 14 points (all positive items) for longitudinal studies and 11 for observational and cross-sectional studies. According to the Quality Assessment Tool for Observational Cohort and Cross-sectional Studies, score ranges were categorized into the following 3 categories for longitudinal studies: high quality ($>$9 points), medium quality (4$-$9 points), and low quality ($<$4 points); and for cross-sectional studies: high quality ($>$7 points), medium quality (3$-$7 points), and low quality ($<$3 points), respectively.

2.7. Outcome measures

Meeting all the 24-Hour Movement Guidelines and meeting none of the guidelines was calculated based on the raw numerators and denominators found among the studies.

2.8. Synthesis methods

Using Stata (Version 16.1; StataCorp., College Station, TX, USA) and the *metaprop procedure*,[19] the prevalence of multiple studies was pooled by applying a random-effects model that displayed the results as forest plots using the DerSimonian and Laird method. The exact or Clopper-Pearson method was used to establish 95% confidence intervals (95%CIs) for prevalence from the selected individual studies,[20] and a Freeman-Tukey transformation was used to normalize the results before calculating the pooled prevalence.[21] An analysis of variance−like random-effects model developed for meta-analytic research was also used to compare differences in adherence to the 24-Hour Movement Guidelines and/or none of these guidelines between sexes, age groups, and regions. Outcome prevalence and respective 95%CIs are presented.

Metaprop tests for intragroup heterogeneity of pooled proportions were also calculated using the I^2 statistic and its p value. Small-study effects and publication bias were examined using the Doi plot and the Luis Furuya-Kanamori (LFK) index.[22] No asymmetry, minor asymmetry, or major asymmetry were considered with values of < -2, between -2 and -1, and > -1, respectively.[22]

Sub-group analyses were conducted by age groups (preschoolers, children, and adolescents), geographical regions (Africa, Asia, Europe, North America, Oceania, and South America), and sex. Finally, random-effects meta-regression analyses using the method of moments were estimated to independently assess whether (non)adherence to the 24-Hour Movement Guidelines differed by country HDI (as a continuous variable) (Supplementary Table 2). The HDI is a composite index measuring average achievements in 3 basic dimensions of human development: a long and healthy life, knowledge, and a decent standard of living.[23] The 2020 Human Development Report introduced a system of fixed cut-off points to classify the HDI into 4 categories of human development achievement: low (HDI: <0.550), medium (HDI: $0.550-0.599$), high (HDI: $>0.599-0.800$), and very high (HDI: >0.800).[23] In this study, 16 countries have a very high HDI ($n = 383,625$), 5 countries have a high HDI ($n = 2821$), and 2 countries have a medium HDI ($n = 991$).

3. Results

3.1. Study selection

A total of 17,551 records were identified through database searches (Fig. 1). After screening for duplicates, gray literature, and other reasons, 7352 records remained. Finally, 216 records were obtained for full-text review. Of those studies, 153 were excluded for several reasons (Supplementary Table 3). Finally, 63 studies were included in this systematic review, and all studies were included in the meta-analysis.
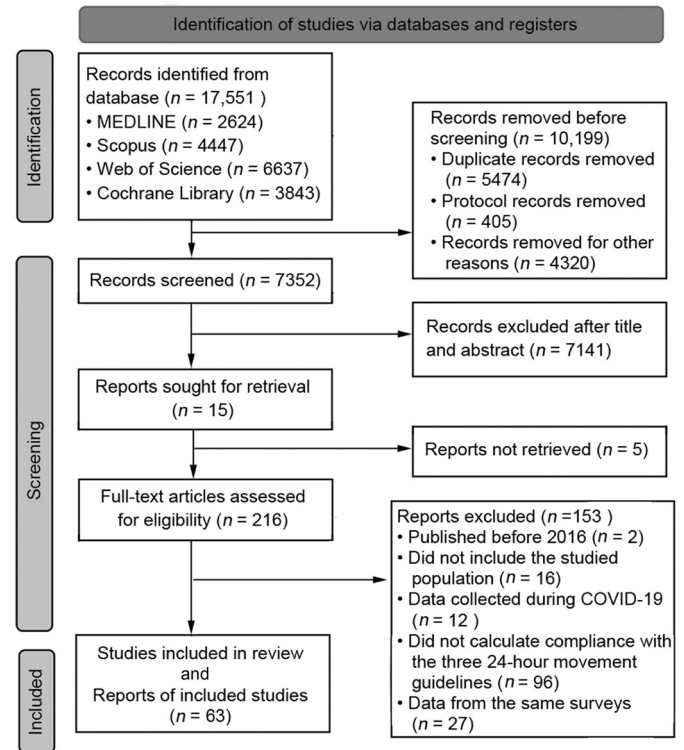

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

3.2. Study characteristics

Summarized in Supplementary Table 2 are the main characteristics of the 63 studies included. Fifty-five of the studies were cross-sectional observational, 7 were longitudinal, and 1 was a quasi-experimental study. A total of 387,437 participants (49% of boys and 51% of girls) aged 3−18 years were included in this systematic review and meta-analysis, of which 11,768 were preschoolers (3−5 years; 3%), 76,928 (6−12 years; 20%) were children, and 298,741 (13−18 years; 77%) were adolescents. Twenty-six studies were conducted with preschoolers only,[8,24,25−48] 13 studies with children only,[49−61] 17 studies with adolescents only,[11,12,60,62−75] and 7 studies with both children and adolescents.[9,10,76−80] According to sex, 25 studies (7 of them with samples of both children and adolescents)[8,10,11,28,31,35,36,42,46,48,50,55−57,61,65−68,70,72,74,76,77,80], reported the overall meeting of 24-Hour Movement Guidelines in both girls and boys, of which 8[8,28,31,35,36,42,46,48] were in preschoolers, 9[50,54−57,61,76,77,80] were in children, 11 studies[11,61,65−68,70,72,74,76,77] were in adolescents, and 7[10,66−68,70,72,76] were in both children and adolescents. In terms of geographical regions, 23 different countries were identified, including 2 in Africa,[39,49,51] 7 in Asia,[11,12,32,33,36,37,45,46,48,49,52,55,63,64,70,72] 7 in Europe,[27,28,30,35,42,49,56,61,65,74,78,81] 2 in North America,[9,10,26,29,34,43,44,47,49,50,57,60,62,66,68,69,71,76,77,25,79,80] 2 in Oceania,[24,31,38,40,41,49,53,58,59,67,75] and 3 in South America.[8,49,54,73] A total of 3 studies were conducted with participants from 2[45] or more different countries.[12,49]

Regarding the measurement of the 3 components of the 24-Hour Movement Guidelines, physical activity was obtained by device-based measures in 37 studies,[8,9,24−31,33−42,43,44, 46,47,49,51−55,59,64,65,73,76,78,81] self-reported measures in 22 studies,[10−12,50,57,58,60−63,66−72,74,75,77,79,80] and parent-reported measures in 4 studies.[32,45,48,56] Screen time was self-reported in 35 studies,[9−12,57−66,67−76,77−81,49−54] and were parent-reported in 28 studies.[8,24−48,52,56] Sleep duration was obtained by device-based measures in 20 studies,[8,9,24,26,31,33,34,37,42,43,47,49,51,53,54,59,64,73,76,78] self-reported measures in 26 studies,[10−12,45,50,55,57,58, 60,61,62,65−72,74−77,79−81] and parent-reported measures in 17 studies.[8,25,27,28,30,32,35,36,38−40,44−46,48,52,56] Study characteristics and (non)adherence to the 24-Hour Movement Guidelines from the 63 studies are presented in Supplementary Table 2.

3.3. Risk of bias in studies and reporting biases

Results of the methodological quality assessment are provided in Supplementary Table 4. Specifically, 77.8% ($n = 49$) of the studies were considered high quality, and 22.2% ($n = 14$) were considered medium quality. Most studies met the reporting criteria about sample (Items 1−4), except for the sample size, which was reported by only 11.11% (Item 5). Since most of the studies had a cross-sectional design, only 11.11% (Item 6) of them conducted a baseline assessment, and 15.87% (Item 7) also failed to justify the exposure time of the intervention. In terms of the independent and dependent variables, 100% of the studies showed different levels of exposure and clearly defined the study variables (Items 8, 9, and 11). However, only 19.05% assessed these variables on more occasions over time (Item 10). Only 1.59% specified whether outcomes assessors were blinded during the study (Item 12), and 7.94% identified losses of participants during follow-up after the initial evaluation (Item 13). Last, most of the studies (88.9%) included covariates related to adherence to the 24-Hour Movement Guidelines (at least sex, age, socioeconomic status, or parental educational level), while 7 (11.1%) did not include them.

3.4. Results of individual studies

Adherence to all and none of the 24-Hour Movement Guidelines for each country by age group and sex is given in Supplementary Table 5 and Supplementary Table 6.

3.5. Results of syntheses

3.5.1. Adherence to the 24-Hour Movement Guidelines

Fig. 2 shows that overall adherence to the 24-Hour Movement Guidelines was 7.12% (95%CI: 6.45%−7.78%; $p < 0.001$) ($I^2 = 99.58$%) in the whole sample. The LFK index for the Doi plots showed a major asymmetry, indicating a major risk of publication bias (LFK index = 4.69) (Supplementary Fig. 1).

The overall adherence was 11.26% (95%CI: 8.68%−13.84%), 10.31% (95%CI: 7.49%−13.12%), and 2.68% (95%CI: 1.78%−3.58%) in preschoolers, children, and adolescents, respectively (Fig. 2). Preschoolers and children had significantly higher adherence than adolescents ($p < 0.001$). There were no significant differences between preschoolers and children ($p = 0.620$) (Fig. 2).

Data analyses revealed that overall adherence was 17.20% (95%CI: 11.24%−23.15%) for Africa, 3.80% (95%CI: 2.78%−4.82%) for Asia, 9.62% (95%CI: 6.81%−12.42) for Europe, 7.88% (95%CI: 6.68%−9.08%) for North America, 10.87% (95%CI: 8.36%−13.38%) for Oceania, and 2.93% (95%CI: 0.01%−5.92%) for South America (Fig. 2).

Overall adherence was significantly lower in girls (3.75%, 95%CI: 3.23%−4.27%) than in boys (6.89%, 95%CI: 5.89%−7.89%) ($p < 0.001$) (Fig. 2). This difference remained in children (girls, 6.94%, 95%CI: 5.01%−8.86% vs. boys, 11.05%, 95%CI: 7.82%−14.29%) (differences between sexes,

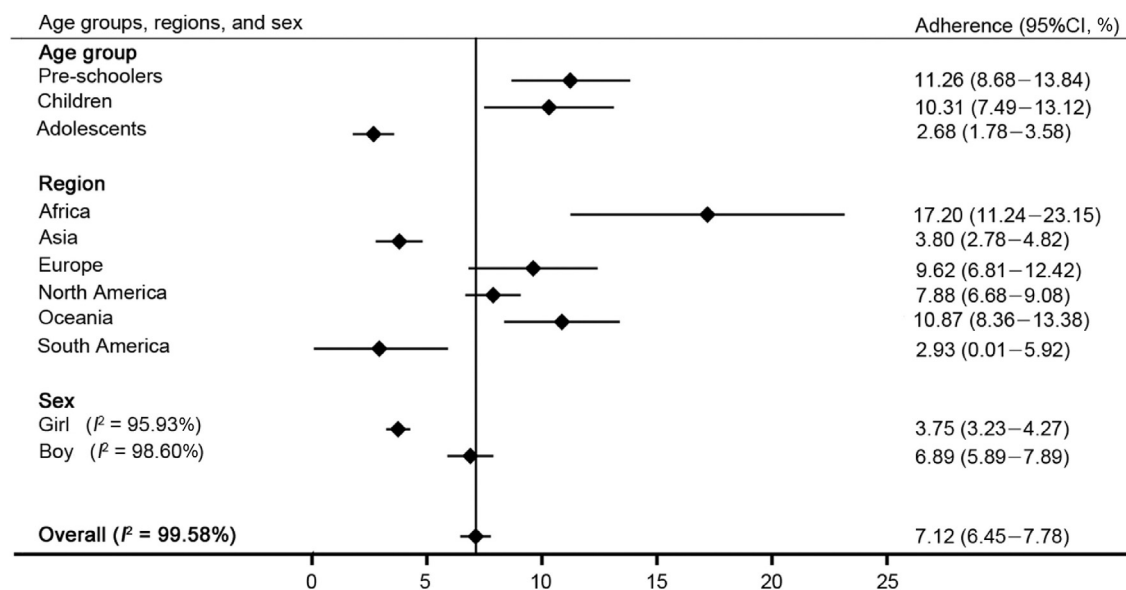| Age groups, regions, and sex	Adherence (95%CI, %)
Age group	
Pre-schoolers	11.26 (8.68−13.84)
Children	10.31 (7.49−13.12)
Adolescents	2.68 (1.78−3.58)
Region	
Africa	17.20 (11.24−23.15)
Asia	3.80 (2.78−4.82)
Europe	9.62 (6.81−12.42)
North America	7.88 (6.68−9.08)
Oceania	10.87 (8.36−13.38)
South America	2.93 (0.01−5.92)
Sex	
Girl ($I^2 = 95.93$%)	3.75 (3.23−4.27)
Boy ($I^2 = 98.60$%)	6.89 (5.89−7.89)
Overall ($I^2 = 99.58$%)	7.12 (6.45−7.78)

Fig. 2. Forest plot of overall adherence to the three 24-Hour Movement Guidelines by age groups, geographical regions, and sex. 95%CI = 95% confidence interval.

$p = 0.030$) but not in preschoolers (girls, 6.92%, 95%CI: 4.11%−9.73% *vs.* boys 8.61%, 95%CI: 5.03%−12.19%) (differences between sexes, $p = 0.470$) or adolescents (girls, 1.86%, 95%CI: 0.98%−2.75% *vs.* boys, 3.54%, 95%CI: 1.67%−5.41%) (differences between sexes, $p = 0.110$) (Fig. 2).

The random-effects meta-regression model showed that overall adherence to the 24-Hour Movement Guidelines was positively associated with country HDI ($\beta = 0.18$, 95%CI: 0.11−0.26; $p < 0.001$) (Fig. 3).

3.5.2. Adherence to none of the three 24-Hour Movement Guidelines

Fig. 4 shows that, in the whole sample, 19.21% of participants did not meet any of the 24-Hour Movement Guidelines (95%CI: 16.73%−21.69%; $p < 0.001$) ($I^2 = 99.82\%$). Clear evidence of publication bias was found (LFK index = 4.52) (Supplementary Fig. 2).

Adherence to none of the three 24-Hour Movement Guidelines in preschoolers, children, and adolescents was 8.81% (95%CI: 5.97%−11.64%), 15.57% (95%CI: 11.60%−19.54%), and 28.59% (95%CI: 22.42%−34.75%), respectively. Preschoolers had significantly lower adherence to none of the three 24-Hour Movement Guidelines than children ($p = 0.010$) and adolescents ($p < 0.001$), whereas children were significantly less likely to adhere to none of the 3 guidelines as compared to adolescents ($p < 0.001$) (Fig. 4).

Geographic data analyses revealed that the pooled prevalence to comply with none of the three 24-Hour Movement Guidelines was 9.99% (95%CI: 0.06%−19.92%) for Africa, 25.77% (95%CI: 19.46%−32.08%) for Asia, 13.48% (95%CI: 8.81%−18.15%) for Europe, 17.70% (95%CI: 13.67%−21.72%) for North America, 11.06% (95%CI: 4.58−17.55) for Oceania, and 31.72% (95%CI: 17.15%−46.29%) for South America (Fig. 4).

Overall, pooled prevalence was slightly higher in girls (15.66%, 95%CI: 8.40%−22.92%) than in boys (12.95%, 95%CI: 6.57%−19.33%), although there were no significant sex differences ($p = 0.580$) in preschoolers (girls, 12.62%, 95%CI:

4.74%−20.50% *vs.* boys, 8.96%, 95%CI: 2.31%−15.61%) ($p = 0.490$), children (girls, 12.20%, 95%CI: 2.99%−21.42% *vs.* boys 13.91%, 95%CI: 3.74%−24.08%) ($p = 0.810$), or adolescents (girls, 14.79%, 95%CI: 7.24%−22.34% *vs.* boys, 10.16%, 95%CI: 4.96%−15.36%) ($p = 0.320$) (Fig. 4).

The random-effects meta-regression model showed that adherence to none of the three 24-Hour Movement Guidelines ($\beta = -0.37$, 95%CI: −0.65 to −0.09; $p = 0.010$) was negatively associated with country HDI (Fig. 5).

4. Discussion

To our knowledge, this is the first meta-analysis that has comprehensively examined the overall (non)adherence to the 24-Hour Movement Guidelines from preschool to adolescence in terms of age group, sex, geographical regions, and country HDI. The main findings of this study are the following: (a) a total of 7.12% of 387,437 young people from 23 countries met the overall 24-Hour Movement Guidelines, and 19.21% met none of the 3 recommendations; (b) adherence to the 3 components of the 24-Hour Movement Guidelines decreases from preschool to adolescence; (c) the proportion of boys who meet all 3 components of the 24-Hour Movement Guidelines is significantly higher than that of girls; however, there are no significant sex differences in adherence to none of the recommendations; (d) South America is the political region with the lowest adherence to the 24-Hour Movement Guidelines; and (e) adherence and non-adherence to the 24-Hour Movement Guidelines is positively and negatively related to country HDI, respectively. These findings can inform intervention priorities for movement behaviors as a global health initiative to prevent possible health problems among young populations,[7] particularly in countries with lower HDI, and in adolescents and girls. This could also help the 24-Hour Movement Guidelines to spread throughout the world.

4.1. (Non)adherence to the 24-Hour Movement Guidelines

The low proportion of young people aged 3−18 years who met the 24-Hour Movement Guidelines in the present study is consistent with a previous systematic review that reported the overall adherence to the 24-Hour Movement Guidelines was lower than 25%.[7] Moreover, in most of the studies of this systematic review, 1 in 5 young people did not meet any of the 3 recommendations. Not meeting any of the 3 recommendations is of particular concern since no single behavior could buffer the adverse effects of the others.[82] The large proportion of adolescents included in this meta-analysis could explain the low overall adherence to the 24-Hour Movement Guidelines found. Another possible explanation for the low prevalence in the present study might be related to the low adherence to the current recommendations for daily physical activity. For example, in accordance with the present results, a previous study from the World Health Organization demonstrated that only 8% of children aged 6−9 years achieved the best classification in the physical activity-risk behavior score.[83] Another study from 298 school-based surveys from 146 countries, territories, and areas, which included 1.9 million students worldwide, reported
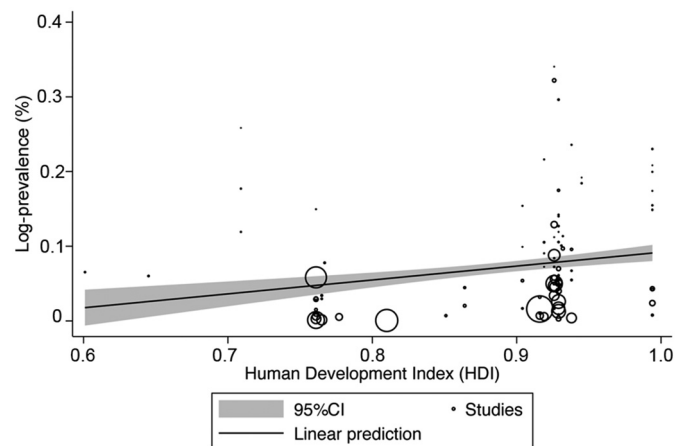

Fig. 3. Association between participants who met the overall 24-Hour Movement Guidelines and the Human Development Index for each country. 95%CI = 95% confidence interval.
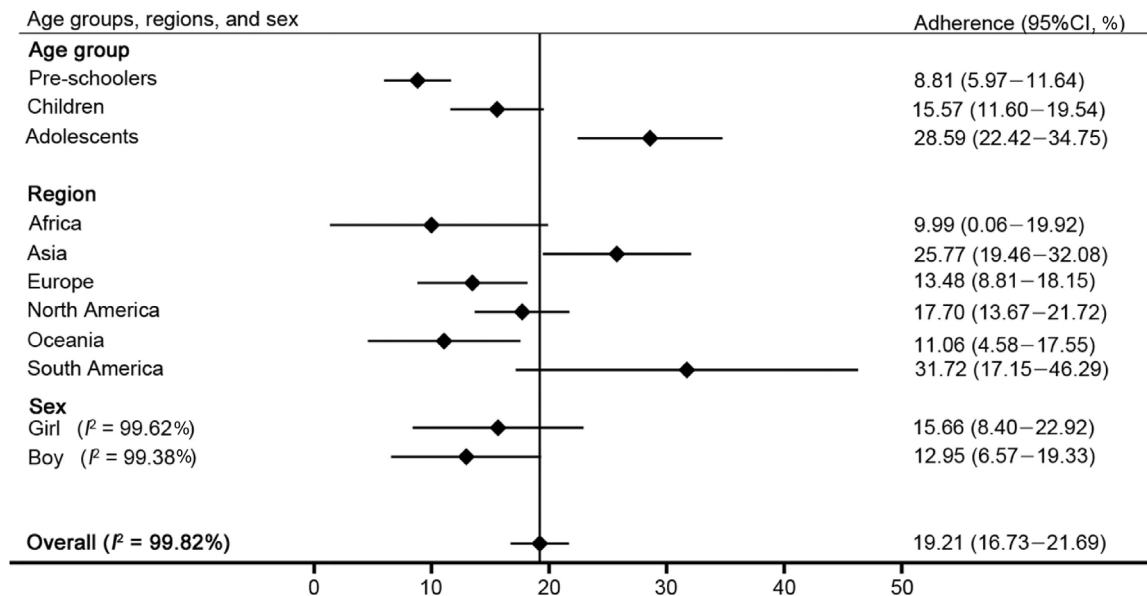
Fig. 4. Forest plot of adherence to none of the three 24-Hour Movement Guidelines by age groups, geographical regions, and sex. 95%CI = 95% confidence interval.

that more than 80% of school-going adolescents aged 11−17 years did not meet daily physical activity recommendations.[84] It is also possible that our results could be explained by the increased rates of leisure-time sedentary behaviors among adolescents, as was shown in a previous study including a large population sample of 26 under-represented countries from 5 World Health Organization-defined geographic regions.[85] Using a large population-based surveillance study of children and adolescents, Thomas et al.[86] also reported that, on average, 52.3% of participants ($n = 19$ studies) exceeded 2 h/day of screen time and that total screen time was 3.6 h/day (range: 1.3−7.9 h/day). Moreover, a systematic review conducted among children and adolescents aged 5−18 years showed that over the last century, sleep duration has decreased

by more than 1 h.[87] In short, the technological revolution of the 21st century may have increased the amount of time spent in a sitting position, thereby reducing the available time to engage in healthy behaviors such as physical activity and sleep.

4.2. Adherence to the 24-Hour Movement Guidelines according to sociodemographic variables

As was previously indicated, increasing age was associated with a lower prevalence of meeting the 24-Hour Movement Guidelines overall. There are several possible explanations for this result. For instance, this finding is consistent with the study conducted by Chemtob et al.[10] that longitudinally examined adherence to the 24-Hour Movement Guidelines from childhood to adolescence. These authors showed that adherence was low in childhood and even lower in adolescence. Supporting this idea, the scientific literature is consistent with the age-related decline in daily physical activity levels from childhood to adolescence.[88] It is also possible that as young people get older, they may also use a greater number and type of electronic devices (e.g., internet mobile connection) with less parental control.[89] In this sense, Chong et al.[51] suggested that this increase in screen time may result from an increase in the autonomy of behavioral choices as children get older. Another possible explanation for this decrease in the adherence to the 24-Hour Movement Guidelines from pre-school to adolescence could be due to a reduction in sleep duration as a result of an increase in academic demands (i.e., time spent doing homework or studying) as young people enter secondary school or to greater time spent pursuing different screen-based behaviors, especially before or during bedtime hours,[90] which perhaps displaces sleep. In addition, previous studies suggest that adolescents may have fewer parental restrictions at
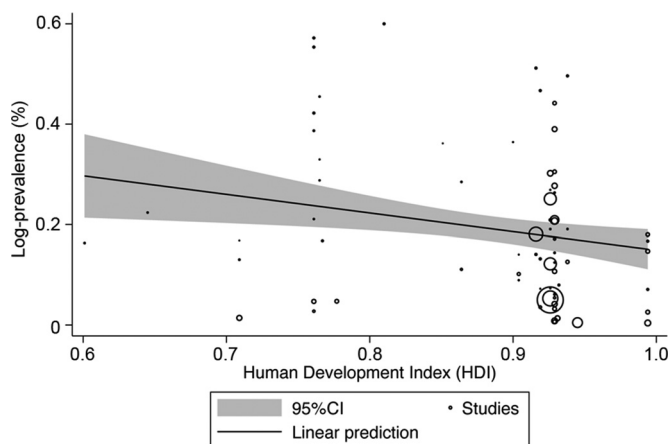

Fig. 5. Association between participants who do not meet any of the three 24-Hour Movement Guidelines and the Human Development Index for each country. 95%CI = 95% confidence interval.

bedtime than do children and preschoolers, which could lead to more late-night screen time and, consequently, shorter sleep duration.[91]

Another important finding in the present study was that analyses stratified by sex revealed that a high proportion of girls failed to meet all 3 recommendations of the 24-Hour Movement Guidelines as compared to boys, although there were no significant differences in the adherence to none of these recommendations between sexes. Overall, it is well-established that boys are more active than girls through childhood and adolescence.[84,92] For example, the above-mentioned study published on more than 1.9 million young people found that across all income groups, world regions, and in almost all countries analyzed, girls were less active than boys. Sex bias in sport, low motivation and perceived competence, or competing priorities during adolescence are some of the main perceived barriers to physical activity among girls.[93] In addition, multi-country studies showed that accelerometry-measured total sedentary time is higher in girls than in boys,[94] which may have a further downstream effect on sleep duration in girls.[95] All these reasons could explain our findings.

The present study also revealed differences in adherence to the 24-Hour Movement Guidelines across geographical regions and country HDI levels. Therefore, these findings support that 24-Hour movement behaviors are affected by social, cultural, and geographical factors. We found that the highest adherence to the overall 24-Hour Movement Guidelines and the lowest prevalence of meeting none of the 3 recommendations was observed in the African region. Caution must be used in generalizing this observation because we only included 2 studies from South Africa,[39,51] a country classified with a high HDI. In contrast, South America was the region with the lowest adherence to the 24-Hour Movement Guidelines, particularly in Brazil.[8,49,73] This result from South American countries could be related to their low adherence to physical activity recommendations and high time spent in sedentary behaviors. For example, data from the Global School-based Student Health Survey (2007−2013) in 26 Latin America and Caribbean countries show that only 15% of adolescents meet physical activity recommendations and that at least 50% of adolescents reported sitting for at least 3 h/day outside of school.[96]

In the present meta-analysis, overall adherence to the 24-Hour Movement Guidelines was positively related to country HDI. It seems possible that these results are due to young people in high HDI countries having a better distribution of time over 24 h than those in medium HDI countries, perhaps because of better overall living and social conditions. These conditions could lead to more opportunities to be active at school and in the community, to achieve better sleep hygiene, and to know the health risks associated with high amount of time spent pursuing screen-based behaviors. Our findings are contrary to previous evidence suggesting that higher country HDI is related to lower physical activity prevalence.[96] The above-mentioned study performed in Latin America and the Caribbean countries also suggested that prevalence of sedentary behavior in adolescents was inversely related to the HDI,[96] which differs substantially from our overall results.

These discrepancies deserve further exploration. Despite this, it should be considered that economic growth is not always accompanied by equality of wealth and opportunities (e.g., health or education access) within countries; this might be the case in Latin American and Caribbean countries.[97]

4.3. Limitations and future perspectives

Our results need to be interpreted in light of several limitations. The fact that the data synthesized in this meta-analysis were pooled from cross-sectional data suggests that causality cannot be inferred from cross-sectional associations between the 24-Hour Movement Guidelines and the demographic variables analyzed. Further longitudinal studies are needed to examine the causality of these relationships. The high variability of both self-reported and device-based measures may introduce bias in the results. Another limitation includes the sometimes-limited validity and reliability of survey instruments to assess recreational screen time guidelines, as well as the different types and number of screen-based behaviors. Current evidence highlights the need for more harmonized device-based physical activity and sleep duration data worldwide for a more fine-grained picture of overall adherence to the 24-Hour Movement Guidelines. Future studies examining the difference in overall adherence to the 24-Hour Movement Guidelines between weekdays and weekends are another avenue of research worth exploring. Another potential limitation, though, is that while studies on adherence to the 24-Hour Movement Guidelines are being conducted in many countries,[7] the 24-Hour Movement Guidelines have only been adopted in Canada, Australia, New Zealand, South Africa, and Asia-Pacific between 2016 and 2021, and this may introduce bias. Finally, most of the data came from very high HDI countries, and there is no country with low HDI. Therefore, the results cannot be generalized to the entire population and should be interpreted with caution.

5. Conclusion

Most young people from the 23 countries surveyed failed to meet the 3 components of the 24-Hour Movement Guidelines. The fact that about 1 in 5 young people did not meet any of the healthy movement behaviors recommendations is a public health concern. Although interventions aimed at improving adherence to the 24-Hour Movement Guidelines are needed in all young people, older children and adolescents and girls (especially those from medium HDI countries) should be targeted as a priority. Hence, these findings emphasize the critical need for integrating sex- and age-specific strategies to support young populations in developing and maintaining healthy movement behaviors over time. Special attention should be given to the South America region given their low adherence to the 24-Hour Movement Guidelines. In line with Sustainable Development Goals, a new global action plan is required not only to increase the proportion of young people who meet physical activity recommendations but also screen time and sleep duration guidelines.

Acknowledgments

Authors' contributions

MATS was responsible for the conceptualization and design of the systematic review and meta-analysis, the screening process, data collection and extraction, risk of bias assessment, and data analysis, as well as the drafting of the original version of the manuscript; JSS conceived the study, participated in its design, conducted the search and identification of studies, checked the information in the selected articles, and helped draft the manuscript in its initial and post-review versions; PASM contributed to data collection and extraction, risk-of-bias assessment, and provided drafting and editorial assistance on the manuscript; JFLG and MST were responsible for drafting and revising the manuscript; AGH contributed to the conceptualization and design of the study, verification of the data, assessment of risk of bias, statistical analyses, interpretation of the data, and coordination and helped draft the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

Supplementary materials

Supplementary materials associated with this article can be found in the online version at doi:10.1016/j.jshs.2022.01.005.

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