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Pooled analysis of physical activity, sedentary behaviour and sleep among children from 33 countries

Kar Hau Chong, PhD, School of Health and Society, Early Start, Faculty of the Arts, Social Science and Humanities, University of Wollongong, NSW 2522, Australia.

Thomas Suesse, PhD, National Institute for Applied Statistics Research Australia, School of Mathematics and Applied Statistics, Faculty of Engineering and Information Sciences, University of Wollongong, Wollongong, NSW 2522, Australia.

Penny L. Cross, BEng (Mat) (Hons), Research Services Office, Research and Innovation Division, University of Wollongong, NSW 2522, Australia.

Sarah T. Ryan, BSc (Hons), School of Health and Society, Early Start, Faculty of the Arts, Social Science and Humanities, University of Wollongong, NSW 2522, Australia.

Eivind Aadland, PhD, Department of Sport, Food and Natural Sciences, Faculty of Education, Arts and Sports, Western Norway University of Applied Sciences, Sogndal, Norway.

Oluwayomi Aoko, MSc, Human Kinetics and Health Education Department, University of Lagos, Lagos, Nigeria.

Ankhmaa Byambaa, BSc (Hons), National Centre for Public Health, Ulaanbaatar 13381, Mongolia.

Valerie Carson, PhD, Faculty of Kinesiology, Sport, and Recreation, University of Alberta, Edmonton, AB, T6G 2H9, Canada.

Jean-Philippe Chaput, PhD, Healthy Active Living and Obesity Research Group, Children's Hospital of Eastern Ontario Research Institute, Ottawa, ON K1H 8L1, Canada.

Hayley Christian, PhD, Telethon Kids Institute, University of Western Australia, Nedlands WA 6009, Australia.

Dylan P. Cliff, PhD, School of Education, Early Start, Faculty of the Arts, Social Sciences and Humanities, University of Wollongong, Northfields Ave, Wollongong NSW 2522, Australia.

Marieke De Craemer, PhD, Department of Rehabilitation Sciences, Ghent University, Corneel Heymanslaan 10, 9000 Ghent, Belgium.

Clarice Maria de Lucena Martins, PhD, Research Centre in Physical Activity, Health and Leisure, and Laboratory for Integrative and Translational Research in Population Health, University of Porto, Porto, Portugal.

Christine Delisle Nyström, PhD, Department of Biosciences and Nutrition, Karolinska Institutet, Neo, 141 83, Huddinge, Sweden.

Catherine E. Draper, PhD, South African MRC/Wits Developmental Pathways for Health Research Unit, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa.

Asmaa El Hamdouchi, PhD, Unité de Recherche en Nutrition et Alimentation, CNESTEN, Rabat, Morocco.

Alex Antonio Florindo, PhD, School of Arts, Sciences, and Humanities, University of Sao Paulo, Brazil.

Hongyan Guan, PhD, Child Healthcare Centre, Nurturing Care Research and Guidance Center, Beijing Municipal Key Laboratory of Child Development and Nutriomics, Capital Institute of Pediatrics, Beijing, China.

Amy S. Ha, PhD, Department of Sports Science and Physical Education, Kwok Sports Building, The Chinese University of Hong Kong, Shatin, Hong Kong, China.

Najmeh Hamzavi Zarghani, PhD, Department of Health Education and Health Promotion, Faculty of Medical Science, Tarbiat Modares University, Tehran, Iran.

Kylie D. Hesketh, PhD, Institute for Physical Activity and Nutrition (IPAN), School of Exercise and Nutrition Science, Deakin University, 1 Gheringhap Street, Geelong, VIC 3220, Australia.

Mohammad Sorowar Hossain, PhD, Department of Emerging and Neglected Diseases, Biomedical Research Foundation, Dhaka, Bangladesh.

Jajat Jajat, PhD, Faculty of Sport and Health Education, Universitas Pendidikan Indonesia, Bandung, Jawa Barat, Indonesia.

Thanh Kim, MD, Department of Epidemiology, Faculty of Public Health, Pham Ngoc Thach University of Medicine, Ho Chi Minh City, Vietnam.

Denise Koh, PhD, Centre for Education and Community Well-being, Faculty of Education, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Malaysia.

Anna V. Kontsevaya, PhD, National Medical Research Center for Therapy and Preventive Medicine, 101990 Moscow, Russia.

Nicholas Kuzik, PhD, Children's Hospital of Eastern Ontario Research Institute, Ottawa, ON, Canada.

Marja H. Leppänen, PhD, Institute of Biomedicine, School of Medicine, University of Eastern Finland, Kuopio, Finland.

Marie Löf, PhD, Department of Biosciences and Nutrition, Karolinska Institutet, Neo, 141 83, Huddinge, Sweden.

Himangi Lubree, MSc, Vadu Rural Health Program, KEM Hospital Research Centre, Rasta Peth, Pune, India.

Kim Meredith-Jones, PhD, Department of Medicine, University of Otago, PO Box 56, Dunedin, New Zealand.

Tawonga W. Mwase-Vuma, MPH, Centre for Social Research, University of Malawi, Zomba, Malawi.

Johan Y. Y. Ng, PhD, Department of Sports Science and Physical Education, Kwok Sports Building, The Chinese University of Hong Kong, Shatin, Hong Kong, China.

Rachel Novotny, PhD, Department of Human Nutrition, Food and Animal Sciences, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, Honolulu, HI, 96822, USA.

Jackline Jema Nusurupia, MSc, Tanzania Food and Nutrition Centre, 22 Barack Obama Road, Dar es salaam, Tanzania.

Bang N. Pham, PhD, Papua New Guinea Institute of Medical Research, Goroka, Papua New Guinea.

Bee Koon Poh, PhD, Centre for Community Health Studies (ReaCH), Faculty of Health Sciences, Universiti Kebangsaan Malaysia, 50300 Kuala Lumpur, Malaysia.

John J. Reilly, PhD, Department of Psychological Sciences & Health, University of Strathclyde, Glasgow, Scotland.

Amanda E. Staiano, PhD, Division of Population and Public Health Science, Pennington Biomedical Research Center, Baton Rouge, LA United States.

Kuston Sultoni, MPd, Faculty of Sport and Health Education, Universitas Pendidikan Indonesia, Bandung, Jawa Barat, Indonesia.

Chiaki Tanaka, PhD, Department of Human Nutrition, Tokyo Kasei Gakuin University, 22 Sanbancho, Chiyoda-ku, Tokyo, 102-8341 Japan.

Hong K. Tang, PhD, Department of Epidemiology, Faculty of Public Health, Pham Ngoc Thach University of Medicine, Ho Chi Minh City, Vietnam.

Rachael Taylor, PhD, Department of Medicine, University of Otago, PO Box 56, Dunedin, New Zealand.

Simone A. Tomaz, PhD, Faculty of Health Sciences and Sport, University of Stirling, UK.

Mark S. Tremblay, PhD, Children's Hospital of Eastern Ontario Research Institute and Department of Pediatrics, University of Ottawa, Ottawa, Canada.

Stewart G. Trost, PhD, School of Human Movement and Nutrition Sciences, University of Queensland, Brisbane QLD 4001, Australia

Ali Turab, MPH, PHC Global, Karachi, Pakistan.

Susana Vale, PhD, ESE, Polytechnic of Porto, 4200-465 Porto, Portugal.

V. Pujitha Wickramasinghe, MD, Department of Paediatrics, Faculty of Medicine, University of Colombo, Sri Lanka.

Anthony D. Okely, EdD, School of Health and Society, Early Start, Faculty of the Arts, Social Science and Humanities, University of Wollongong, NSW 2522, Australia.

Corresponding author:
Kar Hau Chong, PhD, School of Health and Society, Early Start, Faculty of the Arts, Social Science and Humanities, University of Wollongong, NSW 2522, Australia.
Email: khchong@uow.edu.au; Telephone: +614 3240 6560

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Key Points

Question: What is the global proportion of children aged 3- to 4-year-old who met the World Health Organization guidelines for physical activity, sedentary behaviour and sleep?

Findings: Our pooled analyses of 7,017 children across 33 countries showed that only 14.3% of children met the recommendations for physical activity, screen time and sleep duration. While differences were noted between sexes, regions and country income levels, the compliance with the overall guidelines was universally low.

Meaning: Identifying key factors and implementing contextually appropriate, effective programs and policies is essential to tackle movement behaviour inequalities among 3- to 4-year-old children worldwide.

Abstract

Importance: The prevalence estimates of physical activity, sedentary behaviour and sleep (collectively known as movement behaviours) in 3- and 4-year-old children worldwide remains uncertain.

Objective: To report the proportion of 3- and 4-year-old children who met the World Health Organization guidelines for physical activity, sedentary behaviour and sleep across 33 countries.

Design: Pooled analysis of data from 14 cross-sectional studies (2008-2022) identified through systematic reviews and personal networks.

Setting: Thirty-three countries of varying income levels across six geographical regions.

Participants: Each study site needed to have at least 40 children aged 3.0 to 4.9 years with valid accelerometry and parent-/caregiver-reported screen time and sleep duration data.

Exposures: Time spent in physical activity was assessed by re-analysing accelerometry data using a harmonised data processing protocol. Screen time and sleep duration were proxy-reported by parents or caregivers.

Main Outcomes and Measures: The proportion of children who met the World Health Organization guidelines for physical activity (≥ 180 minutes/day of total physical activity and ≥ 60 minutes/day of moderate- to vigorous-intensity physical activity), screen time (≤ 1 hour/day), and sleep duration (10-13 hours/day) was estimated across countries and by World Bank income group and geographical region using meta-analysis.

Results: Of the 7,017 children (51.1% boys) in this pooled analysis, 14.3% (95% CI, 9.7%-20.7%) met the overall guidelines for physical activity, screen time and sleep duration. There was no clear pattern according to income group: the proportion meeting the guidelines was 16.6% (95% CI, 10.4%-25.3%) in low- and lower-middle-income countries, 11.9% (95% CI, 5.9%-22.5%) in upper-middle-income countries, and 14.4% (95% CI, 9.6%-21.1%) in high-income countries. The region with the highest proportion meeting the guidelines was Africa (23.9%; 95% CI, 11.6%-43.0%), while the lowest proportion was the Americas (7.7%, 95% CI, 3.6%-15.8%).

Conclusions and Relevance: Most 3- and 4-year-old children do not meet the current World Health Organization guidelines for physical activity, sedentary behaviour and sleep. Priority must be given to understanding factors that influence these behaviours in this age group and to implementing contextually

appropriate programs and policies proven to be effective in promoting healthy levels of movement behaviours.

Introduction

In 2019, the World Health Organization (WHO) published global guidelines for physical activity (PA), sedentary behaviour and sleep (collectively referred to as movement behaviours) for children under the age of five.[1] These guidelines are based on an integrated movement behaviour paradigm,[2] acknowledging the co-dependencies of these behaviours and their synergistic effects on health. For children aged 3- to 4-year-old, the guidelines recommend participating in at least 180 minutes of PA (of which at least 60 minutes should be of moderate- to vigorous-intensity), not spending more than one hour in sedentary screen time, and having 10-13 hours of good quality sleep in a 24-hour day.[1] Meeting these guidelines is associated with better adiposity status,[3] psychosocial health[4] and motor skills[5,6] in this age group. To increase awareness of the importance of healthy levels of movement behaviours in early childhood, it is important to know the proportion of children meeting the guidelines globally.

Building on the systematic review by Rollo and colleagues[7], 33 articles (representing 21 studies) published during January 2015–August 2022 have examined adherence to the WHO guidelines for children aged 3 and 4 years, with the reported proportions ranged from 0% to 37%. Notably, 17 of the 21 studies (85%) were conducted exclusively in high-income countries, indicating the lack of evidence among lower-income countries. A more recent meta-analysis, including data from 26 articles, reported the overall proportion meeting the guidelines was 11% among children aged 3 to 5 years.[8] These estimates should, however, be interpreted cautiously given the methodological variations across studies, particularly in the accelerometer data processing methods applied to obtain PA estimates. Pooling data from these studies using the same data processing protocols while complementing it with new data from more low- and lower-middle-income countries would allow, for the first time, the ability to report the global proportion of children who meet the WHO guidelines. This will contribute to the limited knowledge base on global prevalence estimates of movement behaviours in young children[9] and inform global and regional policies to promote healthy movement behaviours from an early age.

In this paper, we conducted a pooled analysis to determine the proportion of children aged 3- to 4-year-old who met the WHO recommended levels of PA, sedentary behaviour (operationalised and hereinafter referred to as screen time), and sleep across 33 countries using a harmonised data processing protocol.

Methods

Study design and participants

For the present analyses we collated data from published studies identified through systematic reviews and personal networks. Our updated literature search (eMethods in Supplement), along with the published reviews,[7,8] identified 21 articles from 13 studies that met the inclusion criteria: 1) cross-sectional study that involved children aged 3.0 to 4.9 years, and 2) provided valid accelerometer-measured PA and parent/caregiver-reported screen time and sleep duration data for at least 40 children per study site. Four additional studies were identified through personal communications with the lead investigators, resulting in a total of 17 studies eligible for inclusion (eTable 1 in Supplement). The sample size was selected based on the observation that many studies from low- and lower-middle-income countries were pilot studies and, as such, recruited small, non-representative samples. Therefore, having a larger sample size as the inclusion criteria would limit the scope of our analysis to provide a more global examination of movement behaviours. For the types of measures, we considered only studies that used ActiGraph or Actical accelerometers as they are most frequently used in research and have been validated for measuring PA in young children.[10] We selected only studies that provided parent/caregiver reports of screen time and sleep duration, in line with the body of evidence that guided the development of WHO guidelines.[1]

We approached lead authors and invited them to share their dataset, including accelerometer data files, parent/caregiver-reported screen time and sleep duration, and child's sex and age in months. Following confirmation of data availability and the establishment of data-sharing agreements with respective institutions, we obtained datasets for 14 studies before September 2022 (eTable 2 in Supplement). This study was approved by the University of Wollongong Human Research Ethics Committee (2018/044). All datasets used had prior ethical approval including approval for data sharing and/or obtained additional approval for the purposes of this study. As the analyses used only deidentified data, no additional consent from parents/caregivers was required, as determined by the University of Wollongong Human Research Ethics Committee. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Measurements

PA: Data were collected using ActiGraph (ActiGraph LLC, Pensacola, FL, USA) or Actical (Philips Respironics Inc., Murrysville, PA, USA) accelerometers, worn on the right hip or non-dominant wrist, during waking hours only or 24 hours/day for at least four days (eTable 2 in Supplement). Data were harmonised by re-processing the accelerometer files using ActiLife software (version 6.12.1) (Figure 1). This was not possible with data from the Canadian Health Measures Survey due to data-sharing policies. In this case, we asked the collaborator to re-analyse the data using the same procedure. Data files were re-integrated into 15-second epochs for the analysis of PA. Non-wear time was defined as 20 minutes of consecutive zero counts.[11] Time spent in total PA (TPA) and moderate- to vigorous-intensity PA (MVPA) were calculated using the best available, device- and wear-site-specific cut-points.[12-15] PA data were only included if children had at least three days of accelerometry data, with at least six hours of wear time per day[16] between 5AM and 11PM. Valid weekend day data were not required for inclusion as it does not substantially increase the reliability of PA estimates in this age group.[16]

Screen time: Questionnaire items typically asked parents/caregivers to report the total time their child spent using electronic media for recreational purposes on a typical day (eTable 2 in Supplement). For studies collecting data separately for weekdays and weekend days, the weighted average of screen time was used.

Sleep duration: Questionnaire items typically asked parents/caregivers to report either their child's total hours of sleep per night/24-hour period (including naps) or typical sleep schedule (eTable 2 in Supplement). For studies collecting data separately for weekdays and weekend days, the weighted average of sleep duration was used.

Statistical analysis

Individual-level data were pooled to estimate the proportion of children who met the WHO recommendations for PA, screen time and sleep duration (individually and in combination)[1] across countries, according to the World Bank income classification[17] at the time the data were collected, and by WHO region (eTable 3 in Supplement).

Prior to the analyses, accelerometer variables were adjusted to address discrepancies in accelerometer protocol (waking-hour only vs. 24-hour wear) across studies. As our analyses focused only on PA during waking hours, a linear mixed model[18] was fitted using R package "lme4" (with participants as random intercepts and countries as fixed intercepts) based on day-level data to adjust children with 24-hour-measured accelerometer variables as if they were measured with a waking-hour protocol using the residual method. PA variables were further adjusted for accelerometer wear time using the residual method by fitting a linear mixed model (MVPA and TPA as response variables, wear time as covariate and children as random effects) and using the same average wear time of 662 minutes for all children in all countries. Similar methods were applied to adjust sleep data to account for discrepancies in measures used (nocturnal sleep duration vs. total sleep duration [including naps]).

Using the adjusted data, we conducted a meta-analysis with the R package "meta" ('metamean' function for means and 'metaprop' for proportions using the inverse method and the summary measure 'plogit')[19] to derive aggregated country-level estimates and confidence intervals for each movement behaviour variable. These estimates were used in a subsequent meta-analysis to obtain average estimates and confidence intervals for each income group and region, overall and separately for boys and girls. Following this, a meta-analysis of the pooled estimates across regions was conducted to derive overall estimates. It was not possible to produce valid survey-based estimates due to the lack of population-level data for all countries included. All analyses were conducted using R version 4.3.0.

Results

The analytical sample included 7,017 children (51.1% boys; mean age 4.1±0.5 years) from 33 countries across six regions (4.1% Africa, 21.2% Americas, 3.1% Eastern Mediterranean, 31.8% Europe, 3.4% South-East Asia and 36.4% Western Pacific). Two-thirds (78.1%) of the sample came from high-income countries, followed by low-income and lower-middle-income (12.8%) and upper-middle-income countries (9.1%). The descriptive characteristics of participants are reported in eTable 4 in Supplement.

The proportion of children who met the WHO guidelines is presented in Table 1 and visualised in Figure 2. The overall proportion of children who met all three recommendations was 14.3% (95% CI, 9.7%-20.7%), with a lower proportion in upper-middle-income countries than in low- and lower-middle-income and high-income countries. Higher proportions meeting the guidelines were observed in Africa and Europe, while the lowest proportion was found in the Americas. Similar patterns of sex differences were noted across income groups (except for upper-middle-income countries) and regions, with higher proportions of boys meeting the guidelines. Country-level data on guideline adherence is reported in eTable 5 in Supplement.

The proportion of children who met the sleep duration recommendation was nearly two times higher than that of PA and screen time recommendations (Table 1). Similar patterns were noted across income groups and regions (except for the Americas, where the proportion meeting the PA recommendation was the highest). Concerning sex differences, the proportions meeting the PA recommendation were higher in boys than in girls across income groups and regions. For both screen time and sleep duration recommendations, however, higher adherence was observed in girls than in boys (except for Africa and the Americas, where higher rates were reported in boys for sleep duration and screen time recommendation, respectively).

Discussion

This study is the first to report pooled data on the proportion of 3- to 4-year-old children meeting the WHO global guidelines[1] from a large number of countries of varying incomes across six geographical regions. Overall, 14.3% of children from 33 countries met all three recommendations, with the lowest proportion in upper-middle-income countries and the Americas region. The proportion was generally higher among boys than girls, which appeared due to sex differences in PA.

Early childhood is recognised as a critical window of opportunity for establishing healthy movement behaviour patterns that are important for lifelong health and wellbeing.[9] Our finding of a low proportion of children meeting the overall WHO guidelines across countries and regions poses important implications for future population health if no further actions are taken to address this issue. We also found that the low proportion of children meeting the WHO guidelines was primarily driven by the low adherence to PA or screen time recommendations, which varied by income groupings and regions. This suggests inequalities in movement behaviours worldwide, consistent with the results of a multi-country study involving older children.[20] This finding emphasises the urgent need to address the surveillance and research gaps among underrepresented populations to strengthen the accountability of global health metrics, and inform the development of more inclusive strategies to tackle movement behaviour inequalities. There is also a critical need for contextually relevant and scalable interventions capable of achieving population-wide impacts while reducing inequalities within and between countries.[9]

Our study reinforces the urgency of increasing PA participation in young children worldwide, as less than half of our sample are meeting the PA recommendations. This concern is particularly evident for low- and middle-income countries, possibly due to ongoing rapid urbanisation,[21] which often results in less supportive environments for PA. For example, the decrease in size and availability of green spaces/parks and pedestrian access is evident due to the increased demand for commercial and residential areas and road infrastructure.[22] This, along with parental concerns about child safety from strangers and traffic, reduces opportunities for children to play actively outside.[23] To increase PA participation will require a systems-based approach,[24] involving all relevant stakeholders working together to use their expertise and resources to make changes to systems, environments, and policies.

Less than half of the children in our sample met the screen time recommendation. Notably, adherence was particularly low among children from high-income countries and the Americas region, likely due to their high mobile digital accessibility and ownership.[25] A recent review on parental perceptions of their children's screen time found that most parents acknowledged screen time as a "necessity" in this technological era, and they often used screen-based devices as a distraction (e.g., to keep their child occupied while they are busy), for educational purposes, and as a reward for their children's behaviours.[26] Additionally, the review highlighted that parents expressed difficulty in regulating their child's screen use and knowing how much screen time children should have.[26] The changes in routines and social disruption due to the COVID-19 pandemic may have further increased children's exposure to prolonged screen time,[25] underscoring the importance of better activating the guidelines to assist parents/caregivers in understanding healthy screen use and in establishing boundaries for children's screen usage.

Compared to the PA and screen time recommendations, a higher proportion of children met the sleep duration recommendation – a trend consistent across different income groups and regions, except in the Americas where fewer children met the sleep recommendation compared to PA. This discrepancy may be attributed to the widespread use of screen-based devices in this region, which has been shown to adversely affect sleep outcomes in this age group.[27] It is important to note that this finding was based on parent-reported measures, which tend to overestimate actual sleep duration compared to device-based measures.[28] Further, our study did not assess other aspects of sleep (quality and consistency) due to a lack of available data. Future studies are recommended to explore how adherence to sleep recommendations varies with different measurement methods and examine their associations with health outcomes. This will inform future updates to sleep recommendations, which are currently based predominantly on evidence synthesised from studies using only parent-reported measures.[1]

We found that a higher proportion of boys than girls met all three recommendations. Specifically, a consistently higher proportion of boys met the PA recommendation across all income groupings and regions. This disparity is largely due to environmental and social factors. In some countries, boys often dominate play spaces in public playgrounds.[29] Parents typically grant boys greater freedom, allowing them to play outdoors more frequently with less supervision compared to girls.[23] In contrast, girls tend to receive less social support and encouragement from their parents to participate in outdoor play.[23] PA is also less socially reinforced among girls in many cultures, particularly in the African and Asian context, where girls are encouraged to spend more time indoors and engage in more static types of play (e.g, playing with toys) or activities that are more nurturing or domestic in nature (e.g., doing household chores). This reinforces the need for a holistic approach targeting social and cultural environments to reduce sex inequalities in PA.

A higher proportion of girls met the screen time recommendation than boys. The observed sex differences in screen time may be attributed to the digital divide, especially in low- and lower-middle-income countries where girls are reported to be less likely than boys to own or access digital technologies, even within the same households.[30] This may be related to traditional gender norms in certain cultural contexts, where girls are expected to contribute more to household chores or other routine domestic tasks, leaving them with less leisure time. Because the correlates of screen time are different for boys and girls in this age group,[31] there may be a need for sex-specific strategies to manage young children's screen use.

Consistent with observations in child and adolescent populations,[32] we found a higher proportion of girls that met the sleep duration recommendation. This may be linked to higher screen time among boys, resulting in later bedtimes and shorter sleep compared to girls.[27,32] It is noted that multiple factors, including environmental (e.g., sleeping arrangement) and social-cultural contexts (e.g., bedtime routine), may influence a child's sleep duration differently.[33] This complexity makes it challenging to determine the primary factor contributing to the observed sex differences in sleep duration. Further cross-cultural studies assessing sleep characteristics and associated factors are needed to better understand the mechanisms underlying sex differences in early childhood sleep.

This study has several limitations. First, the dataset used covers only a small proportion of countries globally (~17%), and the sample sizes in most of the included studies were small and not representative of the preschool-aged population in each country. This calls for more large-scale, international studies that employ standardised and culturally appropriate measurement protocols to provide stronger evidence on the global prevalence of movement behaviours in this age group. Second, it is acknowledged that pooling accelerometry data collected using different devices and protocols, even when re-processed with a standardised method, may have introduced biases into the PA estimates. The intensity cutpoints used, though tailored to specific devices and wear-sites, have notable limitations, such as being derived from small calibration studies and lacking robust measurement properties.[34] The best available cutpoints for the wrist-worn Actical accelerometer were based on validation studies in older children (aged 6-11 years),[15] which may have introduced errors in determining PA for the younger children in this study. Additionally, the use of absolute intensity-based cut-points could potentially lead to the misclassification of activity behaviours.[35] Nevertheless, we chose this approach to align with past literature from which the evidence guiding the development of the PA guidelines was derived. Similarly, variations in questions used to assess screen time and sleep duration may have led to varying estimates across studies, subsequently influencing our pooled estimates. More importantly, the evidence supporting the use of the existing measures of movement behaviours is largely based on studies conducted in the Western or high-income countries, with limited evidence on their cross-cultural validity.[10,36] Therefore, our estimates may not accurately reflect the true disparities between countries or regions. Finally, our data were mostly collected more than five years ago and prior to the COVID-19 pandemic. As such, our estimates of movement behaviours may not be generalisable to contemporary young children.

Conclusions

We found that in a large multi-country sample of children, less than one in six met the overall WHO Guidelines. While differences were noted between boys and girls and among regions and income settings, the proportion meeting guidelines was universally low. The WHO recommends a systems-based approach to promote healthy levels of movement behaviours across all ages. At the country level, stakeholders from all sectors must work collaboratively to create an active society by changing social norms and attitudes and by providing places and spaces that support children to move more, be less sedentary, and have adequate sleep. These actions must not leave any country behind to ensure that current gaps in the evidence base are addressed equitably. In many low- and middle-income countries, movement behaviours need to be better anchored to other more salient outcomes, such as school readiness, and framed in the context of other priorities such as food insecurity and undernutrition. Finally, robust surveillance processes are essential for monitoring temporal changes and assessing interventions intended to elicit improvements.

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Concept and design: Okely, Reilly, Tremblay, Chong, Suesse.

Acquisition, analysis, or interpretation of data: All authors.

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Critical review of the manuscript for important intellectual content: All authors.

Statistical analysis: Suesse, Chong.

Administrative, technical, or material support: All authors.

Supervision: Okely.

Non-author contributions

Cecilia H. S. Chan, PhD, Department of Sports Science and Physical Education, Kwok Sports Building, The Chinese University of Hong Kong, Shatin, Hong Kong, China; Contribution: Data acquisition.

Fazlollah Ghofranipour, PhD, Department of Health Education and Health Promotion, Faculty of Medical Science, Tarbiat Modares University, Tehran, Iran; Contribution: Data acquisition.

Adang Suherman, PhD, Faculty of Sport and Health Education, Universitas Pendidikan Indonesia, Bandung, Jawa Barat, Indonesia; Contribution: Data acquisition.

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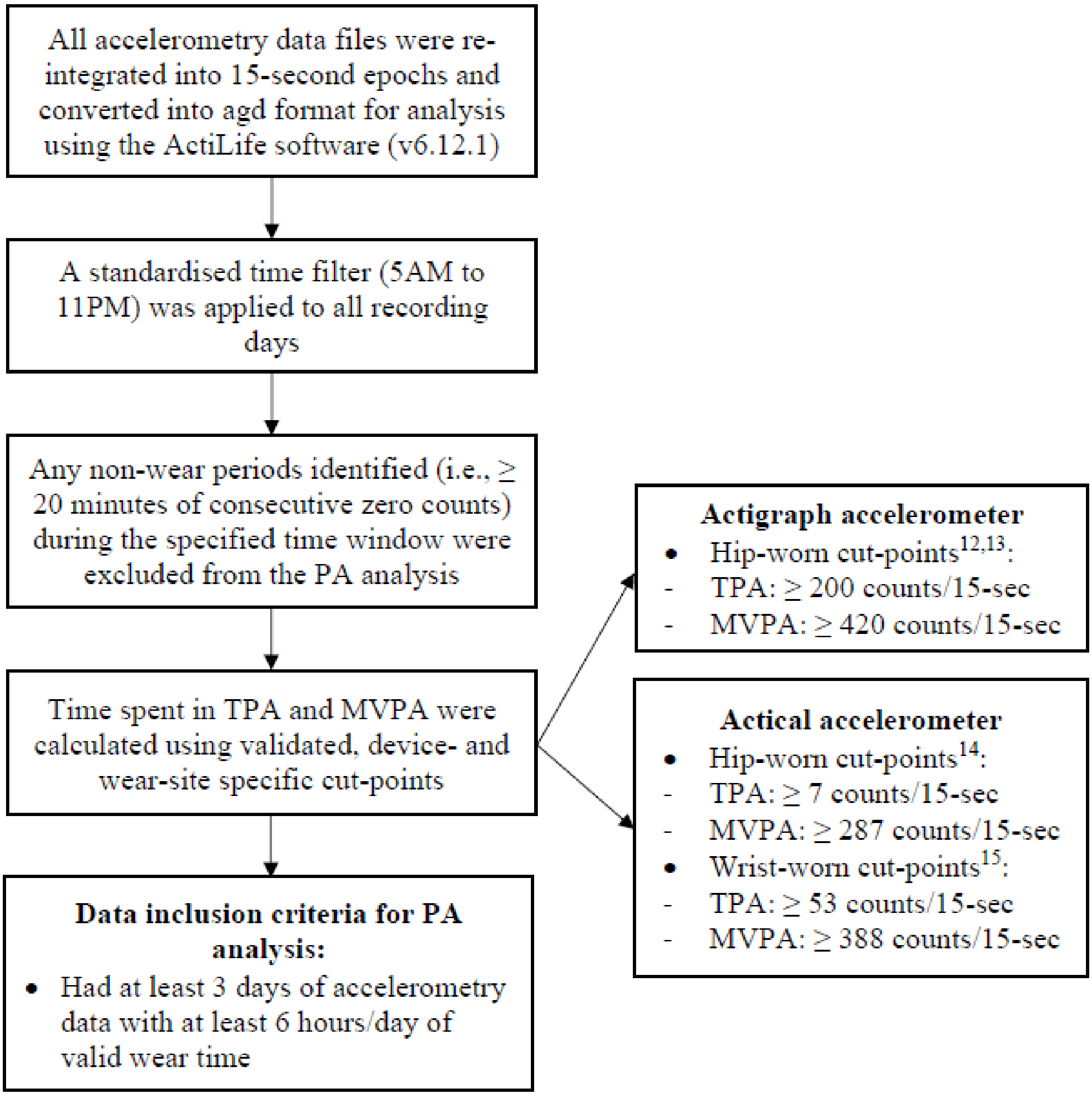
Table 1. Proportion (95% CI) of children meeting the World Health Organization guidelines for physical activity, sedentary behaviour (screen time), and sleep duration

	Physical activity[a]			Sedentary behaviour (Screen time)[b]			Sleep duration[c]			All three recommendations		
	Boys	**Girls**	**Total**	**Boys**	**Girls**	**Total**	**Boys**	**Girls**	**Total**	**Boys**	**Girls**	**Total**
Global Estimate (n=7,017)	55.6 (42.3,68.1)	41.7 (29.3,55.1)	49.2 (36.1,62.3)	38.2 (27.3,50.4)	45.1 (30.7,60.5)	41.8 (29.0,55.9)	78.8 (67.9,86.7)	82.3 (71,89.8)	81.0 (69.7,88.8)	16.8 (12.0,22.9)	12.8 (8.3,19.2)	14.3 (9.7,20.7)
World Bank income groups												
Low/Lower-middle income countries (n=900)	47.2 (35.8,58.9)	35.3 (21.9,51.5)	43.3 (29.7,58.0)	47.2 (33.7,61)	53.3 (37.4,68.5)	49.9 (35.9,64.0)	76.3 (68.7,82.5)	77.8 (70.3,83.8)	77.9 (70.7,83.8)	20.6 (13.6,30.1)	14.9 (8.9,24.0)	16.6 (10.4,25.3)
Upper-middle income countries (n=641)	44.7 (23.9,67.5)	36.6 (11.8,71.2)	43.7 (16.2,75.7)	45.2 (25.0,67.1)	53.0 (29.8,75.0)	50.5 (27.1,73.7)	67.2 (47.9,82.1)	72.1 (55.5,84.2)	71.0 (52.4,84.5)	12.3 (5.8,24.1)	12.3 (6.0,23.6)	11.9 (5.9,22.5)
High-income countries (n=5,476)	71.1 (52.7,84.5)	56.7 (36.4,75.0)	65.4 (45.4,81.2)	31.0 (22.3,41.3)	32.1 (23.9,41.7)	31.3 (22.8,41.2)	84.7 (73.6,91.7)	87.8 (76.9,94.0)	86.7 (75.6,93.1)	16.4 (10.9,23.9)	12.5 (7.7,19.7)	14.4 (9.6,21.1)
WHO Regions												
Africa (n=286)	52.0 (43.2,60.6)	49.2 (34.2,64.4)	50.1 (38.6,61.5)	59.4 (26.7,85.4)	64.8 (33.3,87.1)	62.9 (31.6,86.2)	81.5 (50.4,95)	78.2 (57.1,90.6)	80.3 (55.2,93.1)	24.8 (12.0,44.3)	24.7 (12.9,42.2)	23.9 (11.6,43)
Americas (n=1,487)	72.8 (27.2,95.0)	61.3 (14.0,93.9)	67.6 (20.4,94.4)	17.5 (9.8,29.3)	17.1 (8.4,31.8)	17.0 (9.1,29.7)	62.8 (40.5,80.8)	64.4 (42.2,81.7)	63.5 (41.5,81.0)	9.2 (5.2,15.8)	7.0 (2.4,18.3)	7.7 (3.6,15.8)
Eastern Mediterranean (n=219)	41.2 (25.6,58.8)	28.8 (10.3,58.8)	36.2 (19.0,57.8)	39.7 (16.0,69.5)	60.3 (32.5,82.7)	47.7 (22.8,73.8)	74.9 (53.0,88.7)	84.0 (73.9,90.8)	80.1 (61.8,91.0)	18.5 (6.7,41.8)	14.3 (4.2,39.2)	15.8 (5.2,38.9)
Europe (n=2,232)	62.8 (46.7,76.5)	44.1 (33.0,55.9)	53.5 (40.4,66.1)	43.6 (29.9,58.3)	48.6 (29.3,68.4)	50.0 (27.5,72.5)	93.1 (87.4,96.3)	95.1 (89.7,97.7)	94.7 (89.1,97.5)	26.4 (17.5,37.8)	19.8 (11.8,31.4)	23.5 (14.8,35.1)
South-East Asia (n=240)	33.1 (15.5,57.2)	20.2 (8.5,40.9)	26.0 (12.3,46.9)	35.6 (24.5,48.4)	46.8 (21.3,74.1)	40.6 (22.1,62.2)	75.3 (66.6,82.3)	83.2 (75.2,89.1)	79.7 (74.0,84.3)	13.4 (7.6,22.3)	7.3 (3.1,16.2)	9.1 (4.8,16.6)
Western Pacific (n=2,553)	69.4 (42.5,87.4)	51.5 (24.9,77.3)	62.9 (35.3,84.1)	39.2 (27.6,52.2)	39.3 (27.9,52.1)	39.0 (27.9,51.5)	74.1 (61.4,83.8)	75.2 (62.6,84.6)	75.0 (62.5,84.4)	13.7 (7.9,22.7)	11.0 (6.4,18.3)	12.4 (7.7,19.3)

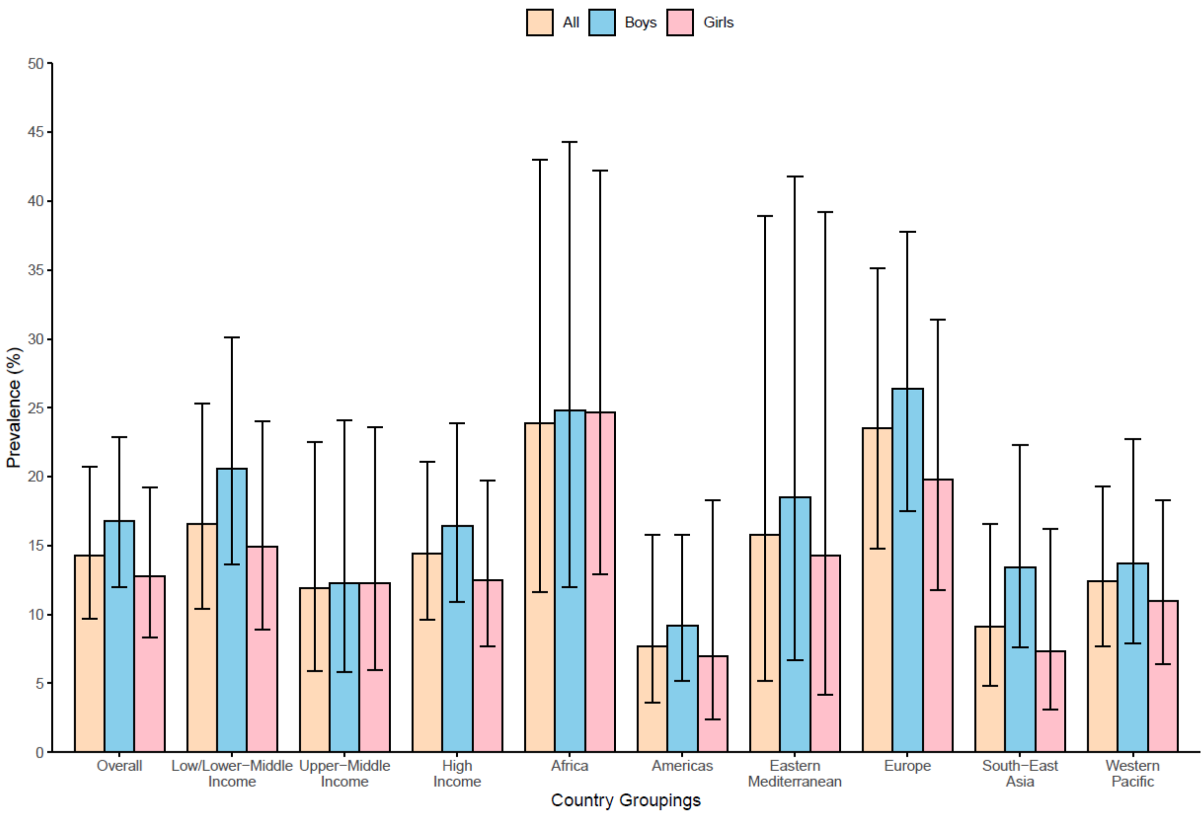
[a]Defined as meeting both the total physical activity (≥ 180 mins/day) and moderate- to vigorous-intensity (≥ 60 mins/day) recommendations.
[b]Not more than one hour of screen time per day.
[c]10 to 13 hours of sleep per day.

Figure 1. Accelerometry data processing and analysis procedures.



Abbreviation: MVPA moderate- to vigorous-intensity physical activity, TPA total physical activity

Figure 2. Proportion of children meeting World Health Organization guidelines, overall and by income group and region.



Note. Data presented as average estimates with 95% confidence intervals.