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Urban Versus Rural Differences in Meeting 24-h Movement Behaviour Guidelines Among 3–4-Year-Olds: An Analysis of SUNRISE Pilot Study Data From 10 Low- and Middle-Income Countries

Jackline J. Nusurupia[1,17] | Leyna H. Germana[1] | Pujitha Wickramasinghe[2] | Hong K. Tang[3] | Nyaradzai Munambah[4] | Mohammad S. Hossain[5,6] | Pham Bang[7] | Guan Hongyan[8] | Alex Antonio Florindo[9] | Catherine E. Draper[10] | Denise Koh[11] | Kuston Sultoni[12] | Anthony D. Okely[13] | Mark S. Tremblay[14,15,16] | Xanne Janssen[17] | John J. Reilly[17]

[1]Department of Community, Health and Nutrition, Tanzania Food and Nutrition Centre, Dar es Salaam, Tanzania | [2]Faculty of Medicine, University of Colombo, Colombo, Sri Lanka | [3]Faculty of Public Health, Pham Ngoc Thach University of Medicine, Ho Chi Minh City, Vietnam | [4]Rehabilitation Sciences Unit, Faculty of Medicine, and Health Sciences, University of Zimbabwe, Harare, Zimbabwe | [5]Department of Emerging and Neglected Diseases, Biomedical Research Foundation, Dhaka, Bangladesh | [6]School of Environment and Life Sciences, Independent University, Dhaka, Bangladesh | [7]Population Health and Demography Unit, PNG Institute of Medical Research, Goroka, Papua New Guinea | [8]Capital Institutes of Paediatrics, Nurturing, Care for Young Children Research and Guidance Centre, Beijing Municipal Key Laboratory of Child Development and Nutriomics, Beijing, China | [9]School of Arts, Sciences and Humanities, University of São Paulo, São Paulo, Brazil | [10]SAMRC Developmental Pathways for Health Research Unit, Department of Paediatrics, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa | [11]Centre for Community Health Studies (ReaCH), Faculty of Health Sciences, Universiti Kebangsaan, Bangi, Malaysia | [12]Faculty of Sport and Health Education, Universitas Pendidikan Indonesia, Bandung, Indonesia | [13]School of Health and Society and Early Start, Faculty of the Arts, Social Sciences and Humanities, University of Wollongong, Wollongong, Australia | [14]Department of Healthy Active Living and Obesity Research Centre, Children's Hospital of Eastern Ontario Research Institute, Ottawa, Canada | [15]Department of Paediatrics, University of Ottawa, Ottawa, Canada | [16]Department of Health Sciences, Carleton University, Ottawa, Canada | [17]Department of Psychological Sciences and Health, Strathclyde University, Glasgow, UK

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ABSTRACT

Background: Insufficient physical activity, excessive screen time and short sleep duration among young children are global public health concerns; however, data on prevalence of meeting World Health Organisation 24-h movement behaviour guidelines for 3–4-year-old children in low- and middle-income countries (LMICs) are limited, and it is unknown whether urbanisation is related to young children's movement behaviours. The present study examined differences in prevalence of meeting 24-h movement behaviour guidelines among 3–4-year-old children living in urban versus rural settings in LMICs.

Methods: The SUNRISE Study recruited 429, 3–4-year-old child/parent dyads from 10 LMICs. Children wore activPAL accelerometers continuously for at least 48 h to assess their physical activity and sleep duration. Screen time and time spent restrained

were assessed via parent questionnaire. Differences in prevalence of meeting guidelines between urban- and rural-dwelling children were examined using chi-square tests.

Results: Physical activity guidelines were met by 17% of children (14% urban vs. 18% rural), sleep guidelines by 57% (61% urban vs. 54% rural), screen time guidelines by 50% (50% urban vs. 50% rural), restrained guidelines by 84% (81% urban vs. 86% rural) and all guidelines combined by 4% (4% urban vs.4% rural). We found no significant differences in meeting the guidelines between urban and rural areas.

Conclusions: Only a small proportion of children in both rural and urban settings met the WHO 24-h movement guidelines. Strategies to improve movement behaviours in LMICs should consider including both rural and urban settings.

1 | Background

Time spent in physical activity, sedentary behaviours (including screen time) and sleep (the 24-h movement behaviours) are crucial to health and development in early life (World Health Organisation (WHO), 2019). During the launch of the World Health Organisation (WHO) guidelines on physical activity, sedentary behaviour and sleep for under 5s in 2019 (World Health Organisation (WHO), 2019), the WHO Director General Dr Tedros Adhanom Ghebreyesus said that 'Early childhood is a period of rapid development when family lifestyles can be adapted to boost health gains'. Improving physical activity, reducing sedentary time and ensuring adequate sleep among young children can improve their physical and mental health in the short- and long-term and help prevent obesity and associated diseases (World Health Organisation (WHO), 2019). Obesity can affect the immediate and long-term health of a child, educational attainment and quality of life (World Health Organisation (WHO) 2016).

The WHO guidelines (World Health Organisation (WHO), 2019) recommended that children aged 3–4 years, in a period of 24 h, should (i) spend 180 min in physical activity (of which at least 60 min should be moderate- to vigorous-intensity physical activity, MVPA); (ii) not be restrained for more than an hour at a time; (iii) not engage in more than 1 h of sedentary screen time; and (iv) have 10–13 h of good quality sleep. To date, various countries have developed, adopted or adapted guidelines for the early years to fit their socio-economic and cultural circumstances. Canada was the first country to develop combined/integrated 24-h movement behaviour guidelines for the early years in 2017 (Tremblay et al. 2017). This was soon followed by Australia (Okely et al. 2017) and New Zealand (New Zealand Ministry of Health 2017). The United Kingdom (UK) guideline development group recommended that 24-h movement behaviour guidelines be adopted for the under 5s, but the UK Health Departments only adopted the guidelines for total physical activity (TPA) and MVPA (Reilly et al. 2019). Among low- and middle-income countries (LMICs), South Africa (Draper et al. 2020) and Thailand (Khamput et al. 2017) have also developed 24-h movement behaviour guidelines for the under 5s.

Since the release of the WHO 24-h movement guidelines for under 5s in 2019 (World Health Organisation (WHO) 2019), research has shown that the prevalence of preschool children meeting these guidelines may be low. For example, a study from Canada (Chaput et al. 2017) found that only 13% of preschool-aged children met the 24-h movement behaviour guidelines, and only around 14% of children from Australia (Cliff et al. 2017). Nevertheless, because most of these studies on the prevalence of meeting the WHO movement behaviour guidelines for 3–4-year-olds were retrospective, that is, not specifically designed to answer research questions about prevalence, it is possible that studies designed to estimate prevalence and differences in prevalence (e.g., between urban- and rural-dwelling children) might produce different results. In addition, most previous studies were conducted in high-income countries (HICs) and very few studies have been conducted in LMICs. For example, in a recent systematic review and meta-analysis of children under 5 years of age (Feng et al. 2021), only one study out of 11 was conducted in LMICs. More recently, some LMICs have begun to conduct research in this area following the development of the International Study of Movement Behaviour in Early Years (SUNRISE) (Okely et al. 2021). SUNRISE was developed with the major aim of determining the proportion of preschool children (3–4-year-olds) meeting the WHO 24-h movement behaviour guidelines for the early years and identifying differences in prevalence of meeting guidelines by factors such as age, gender and urban versus rural living (Okely et al. 2021).

The Behavioural Epidemiology Framework (Sallis, Owen, and Fotheringham 2000) presents a conceptual basis for studying prevalence and correlates of health behaviours (e.g., meeting health behaviour guidelines), so that interventions aimed at improving health behaviours can be developed. This framework notes the importance of identifying if health behaviour guidelines are typically being met or not and emphasises the need to determine which risk factors (e.g., socio-environmental factors such as sex, age, season and socio-economic status [SES]) are related to not meeting guidelines (Sallis, Owen, and Fotheringham 2000). Evidence on the correlates of meeting or not meeting the WHO guidelines will help in determining high-risk groups and provide guidance on how to equitably promote healthier levels of physical activity, sedentary behaviour and sleep in early childhood. At present, it is unclear whether there are marked differences in meeting the 24-h movement behaviour guidelines between children from urban versus rural environments in LMICs (Okely et al. 2021). In sub-Saharan Africa, for example, our previous systematic review found negligible evidence on time spent in the movement behaviours in young children from both urban and rural settings (Nusurupia, Reilly, and Janssen 2021). Some studies (Manyanga et al. 2019; Swindell et al. 2022; Prista et al. 2009) in LMICs have found differences in physical activity between school-aged children and adolescents living in urban and rural settings but whether such differences exist at younger ages, and whether they apply to

the other movement behaviours, is unknown. Therefore, the aim of the present study was to examine in an international cross-sectional study whether urban versus rural living location was associated with the probability of meeting the WHO movement behaviour guidelines in LMICs.

2 | Methods

2.1 | Study Setting

This study used data from 10 countries classified as LMICs based on their economic status using World Bank categories (The World Bank 2024). Participants in the present study were recruited as part of the first and second pilot phases of the SUNRISE Study (Okely et al. 2021; The SUNRISE Study 2024). To participate, children needed to be between the ages of 3.0 and 4.9 years and to be in apparently good health; children with disabilities or other chronic diseases were excluded. In each of the participating SUNRISE countries, a pilot study took place with the aim of recruiting approximately 100 children, with approximately equal numbers of boys and girls and equal numbers from urban and rural settings. Participating countries in the current study were all the SUNRISE LMICs that had completed their feasibility study and used activPAL monitors (PAL Technologies, Glasgow) prior to the COVID-19 pandemic in 2020. The countries included were Bangladesh (lower middle income), Zimbabwe (lower middle income), Vietnam (lower middle income), Sri Lanka (lower middle income), Indonesia (lower middle income), Papua New Guinea (lower middle income), Brazil (upper middle income), China (upper middle income), Malaysia (upper middle income) and South Africa (upper middle income) (The World Bank 2024). The SUNRISE protocol demonstrated a high (Okely et al. 2021) level of feasibility and pilot study data were combined for the present secondary analysis.

2.2 | Measurements of Physical Activity and Sleep

activPAL accelerometers were used to objectively assess the child's time spent asleep, in physical activity and time spent sedentary. The activPAL is currently the only single device that permits measurement of time spent in all of these movement behaviours. The use of activPAL accelerometers in the SUNRISE Study was based on their high reliability and validity for measurement of posture allocation (i.e., lying, sitting and standing) and time spent in physical activity in preschool children (Davies et al. 2012). There are, however, inconsistent results when it comes to the practical utility of the activPAL in children aged 3–4 years: with some showing better compliance than others and a study of high validity for TPA and MVPA, but for an older model of activPAL. It is therefore unclear how accurate the activPAL model used is for the measurement of MVPA and so MVPA was not measured in the present study.

Children were asked to wear the activPAL on their right thigh for 5 days to get at least two full valid days (a valid day was defined as having 24-h of valid data with a minimum of 6 h of valid wear time during waking hours) of data. An output file (event file) was created using the PAL batch software (v8.10: PAL Technologies Ltd, Glasgow) and the standard PAL analysis algorithm (VANE). Full details of measurement procedures are available in the SUNRISE Study protocol paper (Okely et al. 2021) and website (The SUNRISE Study 2024).

Time spent moving (referred to as 'stepping' in activPAL output), referred to as TPA from here onwards because it provides a valid measure of TPA in 3–4-year-old children (Davies et al. 2012), and time spent sleeping were calculated via a custom-made MATLAB program. TPA and sleep time were calculated for each day and then averaged across all valid days for each child. Children were categorised as meeting the TPA guideline if they had at least 180 min of TPA averaged over all included days. Children who spent an average of 10 to 13 h of sleeping were classified as meeting the sleep guideline. Total daily step counts were also measured by activPAL as these provide a valid proxy measure of meeting (at least 11 500 steps/day) or not meeting (less than 11 500 steps/day) the WHO guideline for total time spent in physical activity in 3–4-year olds (Mwase-Vuma et al. 2022).

2.3 | Measurement of Screen Time and Restrained Sitting

Parents were asked to complete a questionnaire reporting the total time their child spent using digital screens per day (minutes/day) (Sallis, Owen, and Fotheringham 2000). All questionnaires were translated into their respective local languages and administered by trained enumerators in each country for clarity. Parents were also asked to report when their child was restrained for more than 1 h at a time (e.g., in a car seat or stroller) (Sallis, Owen, and Fotheringham 2000). Children were categorised as meeting the screen time guideline if they spent ≤ 60 min per day using screen-based electronic devices and children who did not spend more than 1 h at a time restrained were classified as meeting the restrained guidelines.

2.4 | Urban Versus Rural Environment

For categorisation of rural/urban setting, each country provided its own definition as there is no global definition of urban versus rural setting. Based on each country's classification, we then dichotomised the samples as urban or rural (Sallis, Owen, and Fotheringham 2000) and combined the data to make an urban group and rural group as shown in Data S1. Several control variables were captured through the parental questionnaire in the SUNRISE Study (Sallis, Owen, and Fotheringham 2000) including age, sex and SES. SES was derived from parental education level, dichotomised as high (tertiary education or above) or low (secondary/high school or below) education. The SUNRISE Study parent questionnaire was based on a modified version of the WHO STEPwise approach to surveillance (STEPS) questionnaire (World Health Organisation (WHO) 2011; Okely et al. 2021).

2.5 | Statistical Analysis

All statistical analyses were conducted using SPSS version 28. Participant characteristics are presented using descriptive

data analysis, means (SDs) or frequencies (percentages) as appropriate.

Chi-square (χ^2) (categorical variables) and unpaired *t*-tests (continuous variables) were used to examine potential differences between children in urban and rural settings. Using univariate logistic regression analysis, we also examined differences in meeting movement behaviours guidelines between samples from urban and rural settings while controlling for age, sex and SES. A significant association was defined as a *p*-value of < 0.05 for independent sample tests. Using univariate ANOVAs, means were compared between urban and rural settings while controlling for sex, age and SES. Dependent variables were movement behaviours (total sitting time, total standing time, TPA, total steps taken, total sleep time and total screen time).

3 | Results

3.1 | Characteristics of Study Participants

A total of 601 participants consented to participate in the study; 172 children were excluded from the analysis for either having less than two valid days of activPAL data or being outside the age range of 3.0–4.9 years. As a result, a total of 429 children (194 from rural areas and 235 from urban areas) were included in the final analysis.

Table 1 shows the descriptive characteristics of the sample. The mean age was 4.3 (0.4) years, 218 were boys (51%) and 175 of the parents had high SES (41%). Out of the 429 children, 235 were living in rural areas (55%). Data S2 provides descriptive characteristics of 497 children who had completed 1 day's worth of accelerometer data for analysis (i.e., 1 × 24 h period).

3.2 | Meeting Individual Movement Behaviour Guidelines in Urban and Rural Settings

Table 2 shows the percentage of children meeting and not meeting the guidelines in urban and rural settings. No significant differences were found in the prevalence of meeting any of the movement guidelines between urban and rural participants.

3.3 | A Comparison of Continuous Variables Using Univariate Analysis of Variance

Children in urban settings sat for a longer period of time than those in rural settings after controlling for sex, age and SES ($F(1, 382) = 4.94$, $p = 0.027$).

There was no significant difference between urban versus rural settings for total standing time ($F(1, 392) = 0.622$, $p = 0.431$), TPA ($F(1, 392) = 1.554$, $p = 0.213$), total steps taken ($F(1, 392) = 2.068$, $p = 0.151$), time spent in sleep ($F(1, 392) = 1.033$, $p = 0.310$) or screen time ($F(1, 383) = 0.402$, $p = 0.526$), after controlling for sex, age and SES.

3.4 | Differences in Meeting Behaviour Guidelines Between Urban and Rural Settings

After controlling for sex, age and SES, urban versus rural setting was not significantly associated with meeting the physical activity guidelines (OR = 1.29, 95% CI = 0.71–2.36, $p = 0.40$), screen time guidelines (OR = 1.17, 95% CI = 0.77–1.78, $p = 0.47$), restrained time guidelines (OR = 1.35, 95% CI = 0.78–2.33, $p = 0.28$) or meeting all the guidelines (OR = 0.97, 95% CI = 0.31–3.00, $p = 0.95$). However, meeting the sleep time guideline was close to statistical significance (OR = 0.66, 95% CI = 0.43–1.00, $p = 0.05$), with rural children being less likely to meet the sleep time guidelines compared with those living in urban areas.

TABLE 1 | Descriptive characteristics mean (SD).

Variables	All ($n = 429$)	Urban ($n = 194$)	Rural ($n = 235$)	p[c]
Age years	4.3 (0.4)	4.3 (0.4)	4.4 (0.4)	0.005
Sex boys % (n)	51 (218)	55 (106)	48 (112)	0.174
Socio-economic status[a] high % (n)	41 (175)	58 (106)	32 (69)	**< 0.001**
Total sitting time minutes/day	442 (96)	459 (92)	429 (98)	**0.001**
Total standing time minutes/day	210 (59)	205 (59)	216 (58)	0.057
Total physical activity minutes/day	137 (52)	132 (52)	142 (52)	0.050
Total steps/day	10 338 (4425)	9830 (4281)	10 757 (4506)	**0.031**
Total sleep time minutes/day	649 (97)	644 (83)	654 (106)	0.322
Screen time minutes/day[b]	104 (94)	104 (91)	104 (96)	0.997

Note: SES was measured using the level of parental education.
Abbreviation: SD = standard deviation.
[a]$n = 175$.
[b]$n = 419$.
[c]*p*-value for independent *t*-test or chi-square.

TABLE 2 | Prevalence of meeting the guidelines in rural and urban areas % (*n*).

Variables	Total meeting guideline for both settings (*n* = 429)	Urban (*n* = 194)	Rural (*n* = 235)	*p*
Meeting the total physical activity guideline	17 (71)	14 (28)	18% (43)	0.284
Meeting sleep guideline	57 (244)	61 (118)	54 (126)	0.134
Meeting screen time guideline[a]	50 (211)	50 (96)	50 (115)	0.971
Meeting restrained guideline	84 (359)	81 (157)	86 (202)	0.161
Meeting all the guidelines[a]	4 (17)	4 (7)	4 (10)	0.709

[a]*n* = 419; *p*-value for chi-square.

4 | Discussion

4.1 | Main Findings

This study aimed to investigate whether setting (urban vs. rural) was associated with meeting the WHO 2019 movement behaviour guidelines in 3–4-year-olds from LMICs. We found that the majority of children from LMICs did not meet the WHO 24-h movement guidelines and urban versus rural differences in prevalence of meeting guidelines were small. The present study suggests that not meeting the movement behaviour guidelines might be common among young children in many LMICs, even in rural settings. If confirmed by larger future studies, then research and surveillance with young children in 3–4-year-olds globally might need to have more of a focus on rural settings.

4.2 | What Is Already Known on This Topic?

Health and development are profoundly impacted by movement behaviours during the early years (World Health Organisation (WHO 2019; Okely et al. 2021), but the published evidence comes mostly from HICs (Santos et al. 2017; De Craemer et al. 2018), and there is a dearth of evidence or urban–rural differences in the movement behaviours in LMICs.

4.3 | What This Study Adds

The prevalence of meeting 24-h movement behaviour guidelines was low and did not differ significantly between urban and rural settings. Despite perceptions that young children are naturally active (Wachira 2021), the present study revealed low levels of physical activity and high screen time among both urban- and rural-dwelling children, similar to findings in HICs (Kabali et al. 2015; Hinkley et al. 2018). These findings raise concerns regarding health and development impacts, including longer term implications for NCD prevention (Saunders and Vallance 2017; Poitras et al. 2017), highlighting the possible need for initiatives aimed at increasing physical activity and reducing screen time among young children.

Generally, urban environments are associated with more sedentary lifestyles and higher rates of obesity among children because of factors such as increased screen time and limited access to safe outdoor spaces for physical activity (Swindell et al. 2022; Ojiambo et al. 2012). On the other hand, rural settings may have more opportunities for physical activity because of active transportation and greater accessibility of open spaces. However, the present study found negligible differences in movement behaviours between rural and urban settings in 3–4-year-olds. This similarity might be due to the physical activity transition, which is characterised by declining physical activity and increasing sedentary time as countries experience economic development. The present study suggests that this transition may be now occurring in both rural and urban settings of the LMICs, resulting in smaller differences between these settings compared with what might have been observed prior to the transition (Muthuri et al. 2014; Katzmarzyk and Mason 2009).

Despite these trends, rural populations are often underrepresented in global movement behaviour surveillance, particularly in LMICs (Reilly et al. 2022). Most studies focus on urban samples and how urbanisation has impacted health and development. This may be due to logistical challenges in conducting surveillance in rural areas and an assumption that urban settings face more significant issues related to movement behaviours. The present study is consistent with previous criticism (Aubert et al. 2021) that future surveillance of movement behaviours should encompass both rural and urban settings. A more comprehensive understanding of movement behaviour differences between settings will enable LMICs to enhance their public health policies and interventions, better addressing the noncommunicable disease crisis and the ongoing physical activity transition.

Future research should explore the determinants of these movement behaviours in urban and rural settings in LMICs so that intervention can be developed. Such research should consider 'upstream' determinants such as air pollution and safety (road safety and crime). Further research will be needed to better understand the influences on movement behaviours in LMICs and how they vary between and within both urban and rural settings to ensure that future interventions can be appropriately informed and tailored to the challenges faced by these communities.

4.4 | Strength and Limitations of the Present Study

There are several strengths of the present study. First, it was a novel study in LMICs as noted above. Second, the present study used the SUNRISE protocol, which has proven practical and culturally appropriate for LMICs, and movement behaviours were objectively measured with the same device (Okely et al. 2021). Third, most previous studies focused on individual movement behaviours, whereas the present study included all of the movement behaviours, with objective measurement of time spent in physical activity, sedentary behaviour and sleep. Finally, a novel aspect of the study was the comparison between rural and urban settings in early childhood and in LMICs.

However, the present study had some limitations that should also be noted. First, convenience sampling was sufficient for feasibility testing in the SUNRISE pilot studies, but larger and more representative samples will be required to obtain more precise estimates of the prevalence of meeting movement behaviour guidelines—the SUNRISE 'main studies' (Okely et al. 2021) are intended to do just that in future. Second, having device-measured time spent in physical activity and sleep were major strengths, but some variables can only be measured by parent proxy reports at the moment (screen time, restrained time), and there was no alternative method. Third, there was a variation in the definition of rural and urban settings depending on the local context of the country, which may have influenced the interpretation and generalisability of the results. Although future studies, such as the SUNRISE main study, will need to address these issues and refine methodologies for defining urban and rural contexts, this study identified a knowledge gap that still needs to be addressed.

The present study was not powered to make comparisons between two groups (i.e., children living in rural and urban settings) as sample size was fixed by the number of study participants and number of participating LMICs available at the time, but the present study should assist future power calculations. In addition, as noted above, data on movement behaviours from 3–4-year-olds in LMICs is extremely scarce and so the value of the present study lies in adding to a very limited evidence base and providing preliminary data to inform future larger and more robust studies. The preliminary results of the current study suggest that differences between groups might be small. Further larger studies will be needed to confirm our findings but also to examine the reasons for any differences or lack of differences between urban and rural settings.

The SUNRISE Study (Okely et al. 2021)—funding permitting—will move on to larger scale studies that test for urban and rural differences more definitively across a range of different LMICs. Finally, the activPal model used in the present study provides valid measures of TPA (Davies et al. 2012) but has not yet been validated for measurement of MVPA in this age group, but the low levels of TPA observed in the present study suggest that levels of MVPA were probably also low.

5 | Conclusion

Only a small proportion of LMIC children who lived in both rural and urban settings met the individual and combined movement guidelines in the present study. The present study suggests that there is a need to include both rural and urban settings in future public health surveillance of movement behaviours and in mitigation strategies for the physical activity transition in LMICs.

Author Contributions

Jackline J. Nusurupia: conceptualization, methodology, writing – original draft, writing – review and editing, formal analysis, data curation, visualization. **Leyna H. Germana:** conceptualization, supervision, writing – review and editing. **Pujitha Wickramasinghe:** validation, writing – review and editing, investigation. **Hong K. Tang:** validation, writing – review and editing, investigation. **Nyaradzai Munambah:** investigation, validation, writing – review and editing. **Mohammad S. Hossain:** investigation, validation, writing – review and editing. **Pham Bang:** investigation, methodology, validation, writing – review and editing. **Hongyan Guan:** investigation, validation, writing – review and editing. **Alex Antonio Florindo:** investigation, validation, writing – review and editing. **Catherine E. Draper:** investigation, validation, writing – review and editing. **Denise Koh:** investigation, validation, writing – review and editing. **Kuston Sultoni:** investigation, validation, writing – review and editing. **Anthony D. Okely:** investigation, validation, writing – review and editing. **Mark S. Tremblay:** investigation, writing – review and editing, validation. **Xanne Janssen:** conceptualization, writing – original draft, methodology, writing – review and editing, formal analysis, data curation, supervision, visualization. **John J. Reilly:** conceptualization, writing – original draft, methodology, writing – review and editing, formal analysis, data curation, supervision, visualization.

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Ethics Statement

Ethical approval was obtained from the University of Wollongong, Australia (ref: 2018/044) and in each individual participating country through local ethical review authorities. Parents/guardians provided informed consent for their child's participation in each country.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.