Correlates of compliance with recommended levels of physical activity in children

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The purpose of this study was to describe children’s daily compliance with moderate-to-vigorous physical activity (MVPA) recommendations across a week in different parts of the world, and to identify individual- and school-level correlates that may explain differences in daily MVPA compliance. The sample included 6553 children aged 9–11 years from 12 countries, and multilevel statistical analyses were used, including both child- and school-level variables. Most children did not comply with the MVPA guidelines on a daily basis: Chinese children complied the least, whereas Finnish, Australian, Colombian, UK, and Kenyan children complied the most. Boys (rate ratio [RR] = 1.47) and children with higher unhealthy diet scores (RR = 1.08) complied more, but overweight/obese children (RR = 0.81), earlier maturing children (RR = 0.93), and those who spent more time in screen activities (RR = 0.98) and sleeping (RR = 0.96) had the lowest compliance. At the school level, children with access to playground or sport equipment (RR = 0.88, for both) tended to comply less, whereas those with access to a gymnasium outside the school hours complied more with the MVPA guidelines (RR = 1.14). Significant between-country differences in children’s daily MVPA compliance were observed, reflecting not only site characteristics, but also the importance of individual traits and local school contexts.

The current global physical activity guidelines from the World Health Organization (WHO) recommend that children and youth accumulate at least 60 minutes of moderate-to-vigorous physical activity (MVPA) daily in order to achieve health benefits1. However, questionnaire-based data show that 80.3% of adolescents worldwide are not complying with these recommendations2.

Multi-country data capturing children’s physical activity and sedentariness variability have produced inconsistent conclusions3-8. For example, in a study of European youth from five countries (Belgium, Greece, Hungary, the Netherlands, and Switzerland), Greek children from both sexes spent, in general, more time in sedentary behaviours, while Swiss children not only spent more time in MVPA but also reported the highest compliance with MVPA guidelines (12.5% in girls, 27.8% in boys)3. Further, Riddoch et al.4 and Cooper et al.5 have both reported that, on average, Norwegian children were the most active (when compared with Danish, Estonian, and Portuguese youth4, or when compared with Australian, Danish, English, Estonian, Portuguese, and US youth5).
and, in general, complied more with MVPA guidelines. Overall, the prevalence of youth, aged 5–17 years, meeting MVPA guidelines on a daily basis ranged from 1.9% in girls to 9% in boys when using every monitored and valid day. However, these data came from different sources where accelerometer monitoring ranged from 2 to 7 days; further, the exact number of days children complied with the guidelines was not explicitly reported.

These worldwide differences in children's physical activity levels can be traced to heterogeneity in their biological, developmental, and environmental characteristics. It has been consistently reported that sex, weight status, biological maturation, sleep time, and nutritional habits are relevant correlates of MVPA. Further, children spend much of their waking time at school. It is expected that the school environment provides ample opportunities for children to be physically active because of its social and physical settings, namely campus size or playground areas, sports equipment or facilities, recess periods/lunch breaks, and promotion of students' active transport habits.

Table 1. Descriptive statistics (means ± standard deviations or percentage 95% CI) of child-level variables by study site. BMI = body mass index; MVPA = moderate to vigorous physical activity; PHV = peak height velocity.

Table 1

| Country (site)                        | BMI (kg m⁻²) | Maturity Offset (years from PHV) | Healthy Diet score | Unhealthy Diet score | MVPA (min·day⁻¹) | Screen Time (hours·day⁻¹) | Sleep (hours·day⁻¹) | Percentage of Overweight/Obese | MVPA compliance days |
|---------------------------------------|--------------|----------------------------------|--------------------|----------------------|------------------|---------------------------|---------------------|-------------------------------|---------------------|
| Australia (Adelaide)                  | 18.8 ± 3.4   | −1.7 ± 0.9                       | 0.2 ± 1.0          | −0.3 ± 0.7           | 64.8 ± 23.2      | 2.8 ± 1.8                  | 9.4 ± 0.7            | 37.3% (33.0–41.7)              | 3.3 ± 2.1           |
| Brazil (São Paulo)                    | 19.7 ± 4.4   | −2.0 ± 1.0                       | −0.4 ± 1.0         | 0.1 ± 0.9            | 59.5 ± 26.1      | 3.7 ± 2.3                  | 8.6 ± 0.8            | 44.9% (40.5–49.5)              | 2.9 ± 2.2           |
| Canada (Ottawa)                       | 18.3 ± 3.3   | −1.9 ± 0.9                       | 0.5 ± 1.0          | −0.5 ± 0.6           | 58.7 ± 19.3      | 2.5 ± 1.9                  | 9.1 ± 0.8            | 30.8% (26.9–34.9)              | 2.9 ± 2.1           |
| China (Tianjin)                       | 18.9 ± 4.2   | −2.3 ± 0.8                       | 0.1 ± 0.9          | −0.3 ± 0.9           | 45.2 ± 15.8      | 1.9 ± 1.7                  | 8.8 ± 0.6            | 41.5% (37.2–46.0)              | 1.5 ± 1.7           |
| Colombia (Bogota)                     | 17.6 ± 2.5   | −2.3 ± 0.9                       | −0.5 ± 0.7         | −1.0 ± 0.6           | 68.1 ± 24.8      | 2.9 ± 1.5                  | 8.8 ± 0.8            | 23.1% (20.3–26.1)              | 3.5 ± 2.2           |
| Finland (Helsinki, Tampere, Vantaa)   | 17.7 ± 2.6   | −1.9 ± 0.9                       | −0.2 ± 0.9         | −0.6 ± 0.4           | 70.7 ± 26.4      | 2.8 ± 1.7                  | 8.5 ± 0.9            | 23.8% (20.2–27.7)              | 3.2 ± 1.7           |
| India (Bangalore)                     | 18.0 ± 3.3   | −2.2 ± 1.0                       | −0.1 ± 0.9         | −0.1 ± 0.8           | 49 ± 21.3        | 1.8 ± 1.3                  | 8.6 ± 0.7            | 32.7% (28.8–36.8)              | 1.8 ± 2.0           |
| Kenya (Nairobi)                       | 17.2 ± 3.1   | −1.5 ± 1.1                       | 0.3 ± 1.0          | 0.2 ± 1.0            | 71.6 ± 31.3      | 2.4 ± 1.7                  | 8.6 ± 0.9            | 19.9% (16.1–23.7)              | 3.2 ± 2.2           |
| Portugal (Porto)                      | 19.5 ± 3.4   | −1.9 ± 0.9                       | 0.2 ± 1.0          | −0.4 ± 0.6           | 56.4 ± 21.6      | 2.2 ± 1.5                  | 8.3 ± 0.9            | 46.6% (42.9–50.5)              | 2.6 ± 1.8           |
| South Africa (Cape Town)              | 18.0 ± 3.6   | −2.3 ± 0.9                       | 0.3 ± 1.1          | 1.1 ± 1.2            | 65.1 ± 25.6      | 3.1 ± 2.1                  | 9.2 ± 0.7            | 26.9% (23.0–31.2)              | 3.4 ± 2.4           |
| The United Kingdom (Bath, NE Somerset) | 18.5 ± 3.0   | −1.7 ± 1.9                       | 0.01 ± 0.9         | −0.1 ± 0.7           | 63.4 ± 22.4      | 2.9 ± 1.7                  | 9.5 ± 0.7            | 29.9% (25.8–34.2)              | 3.2 ± 2.0           |
| The United States (Baton Rouge)       | 18.9 ± 3.9   | −2.3 ± 1.0                       | −0.1 ± 1.1         | 0.6 ± 1.3            | 49.8 ± 18.9      | 3.1 ± 2.3                  | 8.9 ± 0.9            | 39.5% (35.2–44.0)              | 1.8 ± 1.7           |

Results

Descriptive statistics for level-1 and level-2 covariates are provided in Tables 1 and 2, respectively. In general (see Table 1), children were about 2 years from their estimated PHV; children from the United Kingdom (UK) and Australian sites were closest to their PHV, while those from the Kenyan site were the furthest (>2.5 years to PHV). Regarding dietary patterns, children from the Colombian site showed the lowest healthy diet score, and those from the Canadian site reported the highest; children from the Finnish site had the lowest unhealthy diet score, while those from the South Africa site showed the highest. Averaged across the week and participants, in seven of the country sites children exceeded the ≥60 min/day MVPA guideline; the lowest average daily MVPA was observed in children from the Chinese site, while those from Kenya and Finland sites showed the highest daily average. In addition, screen time and sleeping varied between about 2–4 and 8–9 hours per day across...
sites, respectively. The prevalence of overweight/obesity (Table 1) ranged from 19.9% (Kenyan site) to 46.6% (Portuguese site), and in 7 of the 12 country sites the prevalence was ≥30%.

Table 2. Descriptive statistics (means ± standard deviations, or percentages) for school-level variables stratified by study site.
Discussion

This study aimed to investigate compliance with MVPA recommendations across a week, as well as to identify its correlates, in a sample of children from a multinational study. The results demonstrated that less than 5% of the total sample complied with the MVPA guidelines every day for a whole week and that approximately one quarter of children attained them on at least 5 days. Cooper et al. investigated daily MVPA compliance in children from ten countries, and the results were quite similar with those observed in the present study, because only 9.0% of the
Table 3. Summary of Results of Mixed Models for the number of MVPA complying days. ¹Rate Ratios; ⁵95% confidence intervals; ***p < 0.001; **p < 0.01; *p < 0.05.
Health Organization (WHO) recommendation, but only the percentage of children achieving the guidelines on each day of the week. It is of interest to note (in data not shown) that, if we considered mean MVPA of valid/measured days in the current study we would conclude that these children generally complied with the guidelines because their mean value was 60.4 ± 24.8 min-day⁻¹, reinforcing the need to consider each child's daily results, and not only the average because it does not reflect real day-to-day accumulation patterns.

The results of the multilevel analysis revealed differences in compliance with the MVPA recommendations across countries. Given that the Chinese site was the reference (they had the lowest compliance), children from several other sites complied significantly more. Other multi-country studies⁴,⁵,¹⁷ have also reported differences in children's MVPA among countries. However, in studies involving only European countries³,⁴, and also data from the International Children's accelerometry Database (ICAD)⁵, no clear trend regarding the effect of country-differences in social conditions on children's physical activity was observed. On the other hand, Onywera et al.¹⁷ reported country-specific data from three nations at different stages of the physical activity transition (Canada, Mexico, Kenya), and Kenyan children had the highest MVPA and that Canadians had the least MVPA. Further, when considering MVPA compliance, although very few studies investigated country differences³,⁵, available results are in line with those considering average MVPA values, suggesting that physical activity levels of children vary across countries. From the most active sites in the present study, three of them are classified as high income countries with high HDI, contrasting with the presumption that children from underdeveloped countries tend to be more physically active⁴. Finnish children were those more likely to comply with the MVPA guidelines and this may be linked to favourable social norms, supportive policies, and high quality walking and cycling infrastructure¹¹. Furthermore, children from the most active sites are highly engaged in the use of active transportation to/from school¹¹ and this routinized behaviour may help explain their greater daily MVPA compliance. This complex scenario reflects the presence of different clusters of social, cultural, economic and environmental factors acting distinctively in the expression of youth active behaviours, namely their MVPA compliance.

There may be a positive link between physical activity levels and healthy diets⁶, although available data with youth have mainly focused in the relationship between diet and sedentary behaviours²². Reports relating physical activity and diet are apparently contradictory²³. For example, Jago et al.⁹ reported that in 10–11-year-old English boys their physical activity was negatively associated with fat intake, but positively associated with total energy and carbohydrate intake; in girls, a positive association was observed between physical activity, fruit and vegetable consumption. On the contrary, Visser et al.²³ did not find a clear relationship between physical activity and diet, reporting no significant associations in girls, while in boys higher consumption of fizzy drinks and savoury snacks were positively associated with MVPA. In the present study, a positive association between unhealthy diet score and MVPA compliance was observed, meaning that children with higher unhealthy diet scores were more likely to achieve the MVPA guidelines. This result was unexpected; however, the relationship between physical activity and dietary intake is complex, and issues such as dietary compensation may be playing a role in explaining this association²⁴.

We found a negative association between screen time and MVPA compliance, and also between sleep duration and MVPA, i.e., children who spend more time in screen activities and who sleep more had a lower rate of MVPA achievement. Although higher amounts of screen time (TV viewing and computer use) has consistently been linked to lower physical activity levels²⁵, the same has not been reported regarding sleep. Some studies show higher sleep duration has been related to higher physical activity levels³, while others have suggested that more physically active children tend to spend less time sleeping⁴, and that this association varies between countries²⁶. One possible explanation for these results is related to the fact that there are only a limited number of hours in the day, such that sleeping longer and spending more time in sedentary activities reduces the available time to be engaged in other activities and, at least, to achieve the MVPA recommendations²⁷.

At the school level, only three variables had statistically significant associations with children's MVPA compliance. Having playground equipment or sport equipment available at the school was negatively related to children's MVPA compliance; on the other hand, the availability of a school gymnasium outside of school hours was positively associated with it. The results with respect to playground and sports equipment were unexpected, and it is difficult to explain these inverse associations. It could be that the presence of this equipment alone is not as important as having unrestricted access and time available to make use of it during the school day. On the other hand, we speculate that having access to physical activity spaces for unstructured and unsupervised play may be highly beneficial to promote children's MVPA levels. The school environment can offer students large spaces for physical activities where they may play freely, especially in non-school time, since during school hours they tend to be involved in many seated academic activities.
This study is not without limitations. First, we did not explore children's physical activity patterns across the whole week, and did not investigate differences in MVPA compliance on school days versus weekend days. Second, although we used an objective instrument to measure physical activity, some physical activities like cycling and swimming were not captured. Third, as per the ISCOLE sampling strategy to maximize variation in socioeconomic status within each site, each sample is not nationally representative. Fourth, the exclusion of children with less than 4 days of valid monitoring may bias the final sample favouring those who complied with the study protocol. Furthermore, in the present study we used ≥4 valid assessment days, and as indicated we included an “offset variable” in our analysis. The offset variable is simply the number of valid assessment days (from 4 to 7) for each observed count. Thus, compliance with MVPA guidelines appropriately considered and controlled for the number of days of measurement. As indicated on data analysis subsection, if two subjects both had two days of MVPA, but their number of valid measurements varied, the statistical model adjusted for this measurement difference appropriately in the statistical analysis. Fifth, the cross-sectional design of the study did not allow for a determination as to whether these relationships change over time. This study also has several strengths, namely its large sample size, with children from countries with different socioeconomic and cultural characteristics comprising the major regions in the world. In addition, computing daily compliance with MVPA recommendations instead of presenting averages of measured days allowed us to better understand children's daily MVPA patterns. Further, the use of a multilevel analysis with a count model allowed for a better integration of information from diverse origins.

In conclusion, we demonstrated that the daily MVPA guidelines were not achieved by most children in this large multi-national sample of children. Moreover, MVPA compliance varied across the world, namely Chinese, Indian, and US sites' children had the lowest compliance, and the most compliant were those from Finland, UK and Colombia. Girls, overweight/obese children, those with lower unhealthy diet score, who accumulate more time in sedentariness, and also spend less time sleeping were less likely to comply with the daily MVPA guidelines. Additionally, significant school-level effects were found (but with different signals), namely access to playground equipment, to a gymnasium and to sport equipment outside of school hours. Taken as a whole, these results reflect the important roles country differences, individual characteristics and local school contexts have on children's daily MVPA accumulation patterns.

Methods

Sample. The present sample comes from ISCOLE, a study conducted at sites in 12 countries (Australia, Brazil, Canada, China, Colombia, Finland, India, Kenya, Portugal, South Africa, UK, and US) from all major regions of the world. A detailed account of the study protocol is published elsewhere38, as well as participation rates and sampling representation within each country site29. It is important to recognize that each ISCOLE data are not representative of each country, but that the sampling strategy was designed to maximize variability in socio-economic status at each site29.

A total of 7023 participants (3783 girls; 3240 boys), aged 9–11 years, were sampled. Following the removal of those with missing data, the analytical sample for the current work was 6553. From 60 possible comparisons (12 country sites by 5 variables), of data between included and excluded subjects, by countries, only 12 significant differences were found for the following three variables: maturity offset (Portugal), unhealthy diet (US, Portugal, South Africa, Kenya, China, India), and sleep time (US, Australia, Kenya, Colombia, China). Written informed consent was obtained from parents/legal guardians of all children who were enrolled in the study. The study was in accordance with the Declaration of Helsinki and all procedures were approved by the Pennington Biomedical Research Center (coordinating centre) institutional review board and the local ethics committee(s) of each participating institution. All the methods were performed in accordance with relevant guidelines and regulations.

Child-level variables. Anthropometry. Standing height, sitting height, and weight were measured according to standardized ISCOLE procedures28. For standing height and sitting height, children were measured without shoes, with their head positioned in the Frankfurt Plane, using a portable stadiometer (Seca 213, Hamburg, Germany); standing height was measured with children fully erect, feet together, and at the end of a deep inhalation, while sitting height was measured with children seated on a table with legs hanging freely and arms resting on the thighs. Leg length was computed by subtracting sitting height from standing height. Weight was determined using a portable Tanita SC-240 body composition analyzer (Tanita, Arlington Heights, IL, US), with children wearing light clothes and without shoes or socks. Each child was measured twice and, when necessary, a third measurement was taken if the difference between the previous two was outside the permissible range for each measure and its replica (0.5 cm for standing height and sitting height; 0.5 kg for weight). The mean value of closest two measures for each variable was computed and used for analysis.

Body mass index (BMI) was computed using the standard formula \[\text{BMI} = \frac{\text{weight(kg)}}{\text{height(m)}^2}\], and children were categorized as normal weight or overweight/obese according to cut-points from the WHO based on BMI z-scores29.

Biological maturation. Biological maturation was computed via maturity offset sex-specific regression equations, which uses age and physical growth characteristics (sitting height, leg length, stature and body mass)31. This method estimates, in decimal years, the status of the child relative to their predicted age at peak height velocity (PHV). A positive maturity offset (+) expresses the number of years a child is beyond PHV; a negative maturity offset (−) indicates the number of years before PHV; a zero value indicates that a child is experiencing his/her PHV.
Food consumption. Food consumption information was obtained using a Food Frequency Questionnaire (FFQ)\(^\text{28}\), adapted from the Health Behaviour in School-aged Children Survey. For the FFQ, children were asked about the frequency of consumption of 23 different types of food groups in a typical week, with response categories from “never” to “more than once a day”. Based on principal components analysis\(^\text{32,33}\), dietary scores were derived for each child from the children’s FFQ food groups as input variables, expressing children’s dietary patterns. The two components were named “unhealthy” (positive loadings for hamburgers, soft drink, fired food, etc.) and “healthy” (positive loadings for vegetables and fruits, etc.)\(^\text{32,33}\).

Physical activity and sleep time. Actigraph GT3X + accelerometers (ActiGraph, Pensacola, FL, US) were used to monitor time spent in MVPA (min·day\(^{-1}\)) and sleep (hours·day\(^{-1}\)). Children were asked to wear the accelerometer at their waist on an elasticized belt placed on the right mid-axillary line 24 hours·day\(^{-1}\), for at least 7 days, including two weekend days. Accelerometer information was divided into daytime activities and nocturnal sleep time using an automated algorithm\(^\text{34,35}\). This algorithm produces more precise estimates of sleep duration, since it captures total sleep time from sleep onset to the end of sleep, including all epochs and wakefulness after onset. Non-wear time during the awakening period was defined as any sequence of at least 20 consecutive minutes of zero activity counts\(^\text{36}\). Cut-points advocated by Evenson et al.\(^\text{37}\) were used to define time spent in MVPA, which was defined as \(\geq 374\) activity counts per 15 second epoch.

To be eligible for primary analyses in ISCOLE\(^\text{28}\), children had to have \(\geq 4\) days including \(\geq 1\) weekend day (from a whole week, from Monday to Sunday) with a minimum of 10 hours of awake wear time per day. From the 7023 children sampled, a total of 6553 (93.3%) were eligible (3559 girls, 2994 boys). The mean weekly sleep time was determined using valid sleep days (total sleep time \(\geq 160\) min) for children with at least 3 valid sleep nights, including at least one weekend night (a total of 6158 children). For the present analysis, our dependent variable was the number of days each child complied with the daily MVPA guidelines during the week, as such, it ranged from 0 (none of the days) to 7 days, and the average of valid days varied from 5.8 (Finnish site) to 6.9 (Chinese site) days.

Sedentariness. Sedentariness is a complex characteristic involving behaviours from different domains at work/school, at home, at transportation, and in leisure-time, that include watching TV, using the computer/games, using motorized transportation, and sitting (reading, talking, doing homework, listening to music). In the present study, screen time was used as a proxy measure of sedentariness. This variable was computed based on children’s answers to questions related to time spent watching TV and playing video/computer games or using the computer unrelated to school work, on both school days and weekend\(^\text{28}\). Answers ranged from 1 to 7 (1: 0 hour; 2: less than 1 hour; 3: 1 hour; 3: 2 hours; 5: 3 hours; 6: 4 hours; 7: 5 or more hours). Individual scores were computed such that responses were analogous to number of hours per day (ranging from 0 to 5, with 0.5 representing “less than 1 hour/day”, and 5 representing “5 or more hours per/day”). Then, individual scores were weighted and averaged to create mean daily scores ((school day\(*5 + \text{weekend}*2)/7)\).

School-level variables. Information concerning the school environment was obtained via a questionnaire (ISCOLE School Environment Questionnaire as presented in Katzmarzyk et al.\(^\text{28}\)) completed by the physical education teacher or the school principal.

School size. School size was defined as the total number of students in each school.

School breaks. The number of daily school breaks of less than 30 minutes (category 1) and 30 or more minutes (category 2) was determined. The total number of breaks in each category is described, varying from 0 to 3 + .

School policies. Information regarding the existence (yes or no) of school written policies or practices for physical activity promotion was queried; similarly, school promotion of students’ active transportation (allowing children to bring their bicycles) was also binary coded. Percentage of individual students’ involvement in physical activity clubs or interschool sports was also obtained and, in both of them, responses were structured in four categories: not available or <10%; 10–24%; 25–49%; and \(\geq 50\). The categories were dummy coded with “not available or <10%” as the reference category.

School facilities and equipment. Information regarding students’ access (yes or no) to school facilities like gymnasia (both during school and outside school hours), indoor and outdoor facilities (outside school hours), and to playground and sport equipment was queried.

Data analysis. Descriptive statistics are presented as means ± standard deviations (SD) and frequencies. Independent samples t-tests were also used with the purpose to verify putative differences between children included in the present study with those excluded within each country, across the following variables: BMI, maturity offset, healthy and unhealthy diet scores, and mean daily sleep time. These were computed in SPSS 21. Winpepi software was used to compute frequencies and confidence intervals for children’s weight status based on BMI, also for each country.

As the dependent variable is a count (i.e., the number of days a child complied with the recommendations of 60 min of MVPA) a Poisson regression was used\(^\text{38}\). In this model, the count followed a Poisson distribution, and model covariates were related to the log of the expected value of the count. This ensured that the predicted count was positive. Exponentiating the regression coefficients of the Poisson model yields rate ratios, which correspond to ratios of the average count per unit change of the covariate. For example, if the covariate was a dummy for sex (0 = girls, 1 = boys), then the exponentiated regression coefficient represented the average count for boys divided
by the average count for girls. Furthermore, given the nature of the clustered data (i.e., children nested within schools) a multilevel Poisson model implemented in SuperMix v.1 software was used. The multilevel model explicitly included a random school effect to account for the effect of the school on the student outcomes, i.e., the use of multilevel models allowed modelling the relationship between children’s MVPA, their individual characteristics and school environmental factors. Thus, students within the same school were allowed to be correlated, and the magnitude of the (variance of the) random school effect indicated the degree of correlation of the students within schools. Given that children from all sites did not have the same number of valid days of measurement, an offset term to adjust for these differences in number of valid days (from 4 to 7) was included in all models. Thus, if two subjects each had two days of MVPA, but their number of valid measurement days differed (say four and seven days), the offset (i.e., number of valid measurement days) ensured that the MVPA rates differed for these two subjects (2/4 vs 2/7). Based on an iterative procedure, all parameters (fixed and random) were simultaneously estimated using a full maximum likelihood approach as described elsewhere. Individual (level-1) covariates included sex (girls were the reference category), BMI (reference was normal weight), maturity offset (as a continuous variable), diet, screen time, and sleep; school (level-2) predictors included school size, number of school breaks (with less than 30 minutes, and with 30 or more minutes), school promotion of students’ active transportation, and students’ access to (1) gymnasium during school hours and outside of school hours, (2) playground equipment, (3) indoor and outdoor facilities outside of school hours, and (4) sport equipment (for all these variables, the answer “yes” was used as the reference category). Finally, because of the relatively small number of sites, dummy variables for country sites were included to account for differences across the twelve country sites (rather than treating country site as a third level in the multilevel model) as advocated by Snijders and Bosker. The statistical modelling was based on a threefold approach: step 1 (model 1) only included the dummy variables for country sites; in step 2 (model 2), children’s characteristics were added as covariates to identify possible modifications in the parameter estimates of model 1; in step 3 (model 3), school (level-2) predictors were added. Significance level was set at 5%.

Data availability. Due to the ethical restrictions placed by the Ethics Committees from the 12 countries, as well as data proprietorship by the coordinating centre at Pennington Biomedical Research Center in Baton Rouge, data cannot be made publicly available. Data will be available upon request, and individuals or readers interested in the data can contact ISCOLE coordinating center (Peter.Katzmarzyk@pbrc.edu).

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T.N.G. collected the data, conceptualized and designed the study, undertook the data analysis and interpretation, and led the writing of the manuscript. D.H. supervised the data analysis and contributed to results interpretation and to drafting the manuscript. P.T.K. conceptualized and designed the study, and contributed to drafting the manuscript. J.M. supervised the data collection and management, conceptualized and designed the study, and contributed to drafting the manuscript. M.F., M.S., V.O., E.V.L., M.S.T., J.-P.C., C.T.-L., O.S., V.M., A.K., R.K., P.Z., G.H., T.O., and C.M. critically revised and edited the manuscript. The final manuscript was read and approved by all authors.

Additional Information
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