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# Are Participant Characteristics from ISCOLE Study Sites Comparable to the Rest of their Country?

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**Running Title:** Generalizability of ISCOLE

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**Abstract**

**Background/Objectives:** The International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE) provides robust, multi-national information on physical activity, diet and weight status in 9-11 year-old children around the world. The purpose of this analysis was to examine the similarities and differences between participant characteristics from ISCOLE sites and data from nationally representative surveys from ISCOLE countries (Australia, Brazil, Canada, China, Colombia, Finland, Kenya, India, Portugal, South Africa, the United Kingdom, and the United States).

**Methods:** Distributions of characteristics were assessed within each ISCOLE country-level database, and compared to published data from national or regional surveys, where available. Variables of comparison were identified *a priori* and included body mass index (BMI), physical activity (accelerometer-determined steps per day), and screen time (child-report).

**Results:** Of twelve countries, data on weight status (BMI) were available in eight countries, data on measured physical activity (steps per day) were available in five countries, and data on self-reported screen time were available in nine countries. The five ISCOLE countries that were part of the Health Behaviour in School-aged Children Survey (i.e., Canada, Finland, Portugal, United Kingdom (England), and United States) also provided comparable data on self-reported physical activity. Available country-specific data often used different measurement tools or cut-points, making direct comparisons difficult. Where possible, ISCOLE data were re-analysed to match country-level data, but this step limited between-country comparisons.

**Conclusions:** From the analyses performed, the ISCOLE data do not seem to be systematically biased; however, due to limitations in data availability, data from ISCOLE should be used with appropriate caution when planning country-level population health interventions. This work highlights the need for harmonized measurement tools around the world while accounting for culturally specific characteristics, and the need for collaboration across study centres and research groups.

**Keywords:** population studies, pediatric, representative, lifestyle

**Trial Registration:** ClinicalTrials.gov: Identifier NCT01722500

**Introduction**

The prevalence of paediatric obesity and related lifestyle behaviors has been examined in many countries; however, the International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE) represents the most up-to-date, directly measured, harmonized study of several countries ranging widely in level of human development.[1] Previous multi-national studies have focused on one geographic region (e.g., HELENA in Europe [Healthy Lifestyle in Europe by Nutrition in Adolescents][2]), or limited their inclusion to developed, or high income countries (e.g., HBSC [Health Behaviour in School-aged Children][3,4]). Further, many previous studies have been limited by small sample sizes, indirect measurements, and/or the inability to generalize their findings to larger populations. With so many small, isolated, and non-representative studies, it becomes difficult to inform population health interventions, especially on a global scale.

ISCOLE aimed to recruit study sites with diverse geographical distribution drawn from low-, middle-, and high-income countries. Participants were recruited in predefined locations within each country, thus the samples were not designed to be nationally representative. However, to aid in interpreting results from ISCOLE, and to make informed recommendations, it is important to understand whether ISCOLE participants are comparable to their country-level peers as a whole, or if they represent a unique subset of the larger population. The purpose of this paper was to determine if ISCOLE data are representative of their site country. This work may be used to better understand the limitations, potential biases and generalizability of ISCOLE results, and to identify current gaps in health and obesity-related data in participating countries.

**Methods**

***International Study of Childhood Obesity, Lifestyle and the Environment***

Details on participant recruitment and sampling strategy have been previously reported.[1] In brief, data collection occurred from September 2011 through December 2013 with a goal of recruiting at least 500 participants, aged 9-11 years, from each study site. Sites made an effort to stratify their sample by indicators of socio-economic status to maximize variability.[1] Many countries included both private and public schools, although all sites limited their data collection to large cities, and urban or

suburban schools (i.e., no country collected data from participants living in remote or rural areas). To ensure that ISCOLE participants represented diverse backgrounds and circumstances, study sites were chosen from diverse geographic regions around the world (i.e., Europe, Africa, the Americas, South Asia, and the Western Pacific) and across different levels of socio-economic indicators (i.e., World Bank classification, Human Development Index, and the Gini Index). The ISCOLE coordinating center, located at the Pennington Biomedical Research Center in Baton Rouge, Louisiana, was responsible for overall administration of the study. This project was approved by the relevant research ethics boards at Pennington Biomedical Research Center, at each ISCOLE study site, and at the respective school boards. Written informed parental consent and child assent were obtained for all participants as required.

ISCOLE variables used for the present analysis were limited to those common in national surveys and surveillance systems, including body mass index (BMI), household income, physical activity and screen time. Anthropometric variables (height, weight, BMI) were collected and calculated following standard procedures and measurement tools.[1] BMI was calculated and weight status was determined using various cut-points (e.g., World Health Organization, US Centers for Disease Control and Prevention) to maximize comparability with nationally representative data. See Supplementary File 1 for additional details on income categories. Accelerometer derived variables (light-, moderate- and vigorous-intensity physical activity, and step counts) were obtained via a 24-hour wear protocol using the waist-worn ActiGraph GT3X+ triaxial accelerometer (ActiGraph LLC, Pensacola, FL, USA) and validated data reduction strategies.[5,6,7] Step counts were calculated using the manufacturer's default filter. Data on behavioral characteristics (e.g., self-reported physical activity, and screen time) were obtained via a child-report questionnaire. For the purpose of this work, physical activity guidelines were defined as ≥60 minutes of daily moderate- to vigorous-intensity physical activity and sedentary behavior guidelines were defined as ≤2 hours of self-reported recreational screen time per day. These guidelines are consistent with those from many countries, including Australia,[8] Canada,[9,10] the U.K.,[11] the U.S.,[12] and the World Health Organization.[13] Socio-economic status was measured via parent-

reported household income. Further details on all measurement procedures and questionnaires used in ISCOLE can be found elsewhere.[1]

### *Nationally representative data*

To gain access to nationally representative data, and to understand the intricacies of the datasets, the primary investigator from each ISCOLE study site was asked to provide information for their respective country. As the primary investigators for ISCOLE were chosen based on their expertise in paediatric obesity research, it was believed that they would be aware of relevant data sources. They were asked to use their best judgement when identifying information; however, some of the available nationally representative data may be considered to be out of date (i.e., >5 years old). The writing group for this paper agreed that it was more important to have comparable and well-collected data (e.g., similar age group, directly measured variables) than to necessarily have the most recent data. See Supplementary File 2 for summaries of included studies.

When no data were available, cells were left blank. It is important to note that all variables included in this paper were identified *a priori* and deemed the most relevant to the ISCOLE project and most likely to be captured in other studies. Therefore, some countries have a greater number of areas with no data than other countries, and this may highlight a paucity of robust data in certain areas.

### Results

ISCOLE data were available for 9-11-year-old children from Australia (n=516), Brazil (n=541), Canada (n=541), China (n=537), Colombia (n=905), Finland (n=525), India (n=584), Kenya (n=563), Portugal (n=724), South Africa (n=513), the U.K. (n=525), and the U.S. (n=554). Characteristics of ISCOLE countries can be found in Table 1, and characteristics of participants from each ISCOLE site can be found in Table 2. The proportion of children overweight or obese, accelerometer-determined steps per day, and the proportion of children exceeding screen time guidelines are presented in Figures 1-3, respectively with additional information presented in Supplementary Files 3-5. Figure 4 shows the proportion of children that self-reported meeting physical activity guidelines (i.e. 60 minutes of moderate- to vigorous-intensity physical activity per day) in ISCOLE, and in the HBSC.

### *Europe* (Finland, Portugal, United Kingdom)

All of the ISCOLE site countries in Europe were classified as high-income countries. They were also all part of the HBSC survey.[4] Based on the results from HBSC, Finland provided self-reported data showing that 38% of 11 year old boys, and 25% of 11 year old girls met physical activity guidelines,[4] which is higher than 22% of 9-11 year old boys and 10% of 9-11 year old girls who self-reported that they met physical activity guidelines in ISCOLE. Additional data from Tammelin et al., and the Foundation for Sport and Health Science, found that Finnish children (aged 9-10 years) accumulated 10,506 steps per day, compared to 10 485 steps per from ISCOLE participants. Data on screen time came from the 2010 HBSC, which reported that 61% of 11 year-old boys, and 58% of 11 year-old girls self-reported that they exceeded screen time recommendations on weekdays. This was lower than in ISCOLE, which showed that 84% of boys, and 74% of girls exceeded the recommendation. We were unable to find any comparable data reporting the proportion of Finnish children considered overweight or obese. Therefore, data from ISCOLE Finland are consistent with previous data for directly measured physical activity (but lower for self-reported physical activity), provide slightly higher estimates for screen time, and inconclusive with respect to weight status.

Portuguese children who were part of the HBSC study self-reported higher physical activity levels (23% of 11 year-old boys, and 14% of 11 year old girls are meeting physical activity guidelines) than self-report data from ISCOLE (9% of boys and 4% of girls).[4] Reports from HBSC suggest 11 year-old children are watching more TV (61% of boys and 60% of girls exceed screen time guidelines) compared to ISCOLE participants (55.3% of boys and 43.0% of girls exceed screen time guidelines). Regarding weight status, Portugal was able to provide comparable data for 10 year-old children from the Plataforma Contra a Obesidade.[14] This showed similar proportions of children considered overweight or obese for boys (50.0% compared to 51.4% in ISCOLE) and girls (45.3 versus 42.3% in ISCOLE). Overall, participants from ISCOLE Portugal reported lower levels of physical activity, but similar levels of screen time, and a similar proportion of children considered overweight or obese compared to other surveys.

Because the ISCOLE site in the U.K. was based in England, we aimed to obtain comparable data from England, rather than across the U.K. wherever possible. Data from England came primarily from

the Millennium Cohort Study (MCS), with additional data coming from HBSC. According to the MCS (children aged 7-8 years), boys averaged 10 739 steps per day and girls averaged 9 699 steps per day.[15] This was very similar to what was seen in ISCOLE with boys averaging 10 675 steps per day and girls averaging 9 435 steps per day. Self-reported data from HBSC showed that 33% of 11 year-old boys and 20% of 11 year-old girls met physical activity guidelines,[4] whereas in ISCOLE, only 19% of boys and 11% of girls self-reported that they met the guidelines. With respect to sedentary behavior, results from the HBSC showed that 64% of 11 year-old boys, and 60% of 11 year-old girls exceeded screen time guidelines on week days;[4] results from ISCOLE show that 73% of boys, and 61% of girls exceeded the guidelines. Compared to data from 10-11 year-old children from the National Child Measurement Programme, there was a lower proportion of children considered overweight or obese in ISCOLE (33.3% versus 21.7% respectively).[16] Data from ISCOLE seem to be comparable with respect to physical activity levels, but with higher levels of screen time. However, it can be assumed that there are variations in the socio-cultural environment across the rest of the U.K and it is recommended that generalizations to a wider population are made with caution.

***Africa*** *(Kenya, South Africa)*

Kenya was the only study included in ISCOLE considered to be a low-income country; South Africa is considered to be an upper-middle income country. Neither Kenya nor South Africa had any nationally representative, or large datasets for comparison. Summaries of the best available evidence for each country was presented in their 2014 Report Card on Physical Activity in Children and Youth and included primarily early results from ISCOLE, suggesting future studies are critically needed.[17,18]

Comparisons for ISCOLE Kenya came from two systematic reviews examining obesity and physical activity transitions in Sub-Saharan Africa.[19,20] One systematic review reported a range of 35-72% of children meeting physical activity guidelines,[19] which is higher than the 11.4% of children who self-reported meeting the guidelines in ISCOLE. A small study examining urban and rural Kenyan children (aged 9-12 years) found that only 13.1% of urban, and no rural children used screens for >11 hours per week.[21] This is much lower than ISCOLE measurements which showed that 53.6 % of children exceeded screen time guidelines. This is consistent with emerging evidence of a physical

activity transition in Kenya.[21] The systematic review examining the overweight and obesity transition included studies that reported proportions of overweight/obesity between 3.2-12.0%,[20] which is lower than 16% found in ISCOLE. However, differences in weight status may be due, in part, to urban and rural differences. Even though there were little comparable data available in Kenya, Nairobi is an urban hub, with a population of over 3 million people, and one could assume that children from urban Nairobi may not be representative of their rural peers.

Although South Africa was not able to provide data from any nationally representative surveys, information from smaller studies suggest that 50-59% of children are meeting physical activity guidelines, and <50% of children are meeting screen time guidelines.[18] These values are more promising than what was shown in ISCOLE, which found that 26.4% of children self-reported meeting physical activity guidelines, and 36.7% reported meeting screen time guidelines. Data from the 2010 Survey of Time of Use suggest that on average, children aged 10-17 years watched 3 hours of TV per day.[22] In ISCOLE, children were asked to self-report habitual TV, video game, and computer use with the highest possible value being "≥5 hours per day". Therefore for analysis, self-reported screen time was presented as a score, rather than total hours of screen time since after 5 hours per day, we could not ascertain the participant's actual amount of screen time. Although ISCOLE can only provide an approximate value for daily screen time, it did appear to be similar to what was reported in the Time of Use survey with children averaging approximately 3.1 hours of screen time and 2.0 hours of TV time per day. We were not able to find any comparable data with respect to weight status. Therefore, children from ISCOLE South Africa seem to be slightly less active than reported in other studies, but seem to engage in similar amounts of screen time.

***The Americas*** *(Brazil, Canada, Colombia, and the United States)*

Canada and the U.S. are both considered high-income countries; whereas Colombia and Brazil are both considered upper-middle-income countries. Canada and the U.S. were able to provide a significant amount of comparable and nationally representative data. Both countries are included in the HBSC, and both have nationally representative surveys (CHMS: Canadian Health Measures Survey,[23] NHANES: National Health and Nutrition Examination Survey (U.S.)).

Brazil provided comparable data for weight status for 10 year-old children from the Brazilian Institute of Geography and Statistics (BIGS),[24] but was unable to provide comparable data for physical activity, or screen time. BIGS reported that 33.1% of their children were considered overweight or obese, compared to a much higher 45.7% of children considered overweight or obese in ISCOLE.

Comparable data for Canada came primarily from the CHMS (with custom analysis for their 2014 Report Card[25]) and showed that only 5% of school-aged children met current Canadian physical activity guidelines.[9,26] However, directly measured physical activity from 6-10 year old children in the CHMS show that ISCOLE children are less active than children from across Canada. In the CHMS boys averaged 13 217 steps per day and girls averaged 11 745 steps per day compared to 9 891 steps per day for boys and 8 591 steps per day for girls.[27] Self-reported data from HBSC showed 31% of boys, and 21% of girls met the physical activity guidelines,[4] which was similar to data from ISCOLE, with 26% of boys, and 18% of girls self-reporting they met guidelines. With respect to screen time, data came from the 2007-2009 CHMS and showed that 31% of children aged 5-11 years exceed screen time guidelines.[27] This was slightly lower than what was seen in ISCOLE Canada, with 54.4% of boys, and 40.2% of girls exceeding guidelines. There was a slightly lower proportion of children considered overweight or obese in ISCOLE (21.9% of boys and 21.7% of girls), compared to reports from the CHMS (31% for boys and 26% for girls). In Canada, ISCOLE participants engaged in similar amounts of self-reported physical activity (but less directly measured physical activity), greater amounts of screen time, and had a lower proportion of children considered overweight or obese.

Comparable data for levels of physical activity in Colombia came from the ENSIN study (Encuesta Nacional de la Situación Nutricional (National Survey of Nutritional Status)),[28] and showed that 26% of children self-reported that they met physical activity guidelines, which is higher than what was seen in ISCOLE (12% meeting guidelines). The ENSIN study also provided comparable data with respect to screen time and weight status. For screen time, ENSIN showed that fewer children (59.4% of boys, and 56.3% of girls) exceeded screen time guidelines than children from ISCOLE (71.6% of boys, and 60.4% of girls).[29] ENSIN also reported a lower proportion of children being overweight or obese than ISCOLE (17.5% in ENSIN compared to 23.3% in ISCOLE).[29] Overall, it appears that children in

ISCOLE self-report engaging in less physical activity and more screen time, and are more likely to be overweight or obese than other Colombian children.

Comparable data for U.S. physical activity levels came primarily from the 2003-2004 NHANES. Accelerometer data showed that 42.0% of children aged 6-11 years were meeting physical activity guidelines,[30,31] and on average, 10 year-old boys were accumulating 10 163 steps per day and girls were accumulating 8 906 steps per day.[32] This was similar to what was seen in ISCOLE, with boys accumulating only 9 261 steps per day, and girls accumulating only 8 078 steps per day. With respect to screen time, data from 2009-2010 NHANES showed that 47.8% of children aged 9-11 years self-reported that they exceeded screen time guidelines.[33] The proportion of children exceeding guidelines was higher in ISCOLE, and in 11 year-old boys and girls from HBSC[4] (Figure 3). In ISCOLE, 68.3% of boys exceeded screen time guidelines, and 56.2% of girls exceeded screen time guidelines. Compared to NHANES, we saw a similar proportion of children considered overweight or obese in ISCOLE (NHANES: boys = 33.2%, girls = 35.2%; ISCOLE boys = 32.4%, girls = 35.6%). In the U.S. sample of ISCOLE, children were less active, and were less likely to meet screen time guidelines, but had similar weight status to children from across the country.

### South Asia (India)

India is the only study site in South Asia, and is considered a lower-middle-income country. We were unable to identify any comparable datasets. Data collected in ISCOLE show that 28.4% of Indian children are meeting physical activity guidelines, 30.8% are meeting screen time guidelines, and 33.7% are considered overweight or obese.

### Western Pacific (Australia, China)

Australia is considered a high-income country and China is considered an upper-middle-income country. Australia provided comparable data via the ANCNPAS (Australian National Children's Nutrition and Physical Activity Survey),[34] the National Health Surveys,[35] and a summary of current evidence via their 2014 Report Card on Physical Activity in Children and Youth.[36] China was able to provide comparable data via the China Health and Nutrition Survey (CHNS).

Comparable data from Australia came primarily from the Australian Bureau of Statistics. These data showed that 20% of children aged 5-17 years self-reported that they met physical activity guidelines.[35] This is consistent with self-reported data from ISCOLE. Australia was also able to provide information from the ANCNPAS showing higher values for number of steps per day (12 230 in ANCNPAS compared to 10 262 in ISCOLE).[34] With respect to screen time, data from the Australian Bureau of Statistics showed that 70% of children aged 5-17 years old exceeded screen time guidelines. This was higher than what was seen in ISCOLE, with only 56% of children exceeding the guidelines. Data from ANCNPAS reported 28.4% of 9-11 year old children to be overweight or obese, which is similar to 26.7% of children considered overweight or obese in ISCOLE. Overall, participants from ISCOLE accumulated similar amounts of physical activity, had lower screen time, and had more favourable weight status than their Australian peers.

China provided comparable data on physical activity, screen time, and weight status via the CHNS (China Health and Nutrition Survey).[37,38] For 6-11 year-olds, the CHNS reported children averaged 60 minutes (boys), and 48 minutes (girls) of physical activity per day, compared to lower levels in ISCOLE (49.5 minutes for boys and 40.5 minutes for girls). Results for screen time showed that 24.9% of boys and girls exceeded screen time guidelines, compared to 35.1% in ISCOLE. However, it is interesting to note that these data came from 2004, and in a longitudinal analysis, the proportion of children who reported >2 hours of screen time per day rose from 5.8% in 1997, to 24.9% in 2004, suggesting data from present day may be more comparable. The proportion of children considered overweight or obese was much higher in ISCOLE than in the CHNS (ISCOLE boys = 50.1%, ISCOLE girls = 30.6%, versus CHNS boys = 16.6% and HBSC boys = 10.9%). ISCOLE China participants accumulated slightly less physical activity and slightly more screen time than other estimates; however, the difference (in screen time at least), may be because ISCOLE data collection has occurred more recently, and may not reflect a true difference. The proportion of ISCOLE participants considered overweight or obese was much higher than previous estimates.

**Discussion**

This study aimed to compare data collected in ISCOLE to data collected via nationally representative studies in all ISCOLE study sites. Of the 12 ISCOLE countries, eight provided data on weight status (BMI), five provided data on objectively measured physical activity (steps per day), and nine provided data on self-reported screen time. The five ISCOLE countries that were part of the HBSC survey provided additional data for self-reported physical activity (meeting physical activity guidelines). When data were available, mean data from the ISCOLE study appears to be relatively similar to country-level data; however, this varied with data availability and quality, and there were no systematic differences across countries or variables. Few countries used the same cut-points or measurement tools in their national studies as ISCOLE when analysing participant characteristics.

Initially, the aim of this study was to compare data from ISCOLE sites to nationally representative data in the site country, to get a crude evaluation of the potential bias in the ISCOLE sample. However, it quickly became apparent that many countries do not collect nationally representative data on physical activity, screen time, or weight status. When data were available, it was collected using different tools or with different methods. For example, we aimed to compare accelerometer-measured daily moderate- to vigorous-intensity physical activity (minutes per day); however, after scoping the literature for comparable country level data, this was not possible. Due to the range of different models of accelerometers, and the different cut-points used to distinguish activity intensity, only two countries (the U.S., and Canada) were able to provide comparable data. No countries that could provide nationally representative accelerometer-measured physical activity data using common cut-points. Therefore, we opted to examine physical activity via steps per day, which can be measured using an accelerometer, or a pedometer. The added benefit of examining steps per day is that the cost of pedometers is quite low, making it more feasible to use them in large, population based studies, or in times where resources are limited.

This work has several strengths and limitations. Many countries could not provide any comparable data and therefore it was difficult for us to determine if ISCOLE participants were similar to other children. This meant that many comparisons could not be made, and in most cases we did not have access to the raw data from nationally representative surveys and could not complete any formal

statistical analysis. This leaves our comparisons open to interpretation, and our judgement on

similarities (or differences) in the data open to criticism. However, we believe this also highlights an

important limitation of making global comparisons from many unconnected (but nationally

representative) studies–and the error of collapsing data that has used inconsistencies in measurement

tools, different cut points, across different research centres and countries, and the unavailability of raw

data. Most of the studies included in this work used different methodologies, and different cut points to

assess similar health variables. For example, BMI is a common measure of adiposity in children, yet

there are four different cut points used, all of which provide different prevalence of

overweight/obesity.[39] ISCOLE recruitment was also limited to urban and suburban schools, and

therefore we cannot account for populations living in rural areas. Previous work has consistently

shown differences in obesity and lifestyle habits between these two groups, and that these differences

may be most important in developing areas.[40–42] The results of this work provide a valuable summary

when developing future research programs and can help inform public health interventions. Another

strength of this work is related to the rigour of the ISCOLE data collection and management

procedures.[1] The ISCOLE framework and coordinating center ensured all study sites, and all ISCOLE

researchers, completed mandatory training for all aspects of the study.

**Conclusions**

This manuscript was designed as a methodological and ecological comparison study that may be

used to provide evidence of the potential bias from each ISCOLE country sample, facilitating future

intra- and inter-country comparisons. Due to the limited availability of country-level data, it is

suggested that ISCOLE data be used with appropriate caution when planning countrywide population

health interventions. However, for many countries ISCOLE currently provides the most up-to-date,

most robust, and sometimes the *only* data on obesity and physical activity in children. This work has

identified the paucity of comparable country data around the world and highlighted the importance of

large, multi-national studies like ISCOLE. Moving forward, we recommend that researchers harmonize

procedures for data collection and analysis. It is important to use the momentum, and collaborations

that were built in ISCOLE to inform public health interventions, as well as other cross-sectional, surveillance surveys.

**Acknowledgements**

**Conflicts of Interest**

MF has received a research grant from Fazer Finland and has received an honorarium for speaking for Merck. AK has been a member of the Advisory Boards of Dupont and McCain Foods. RK has received a research grant from Abbott Nutrition Research and Development. VM is a member of the Scientific Advisory Board of Actigraph and has received an honorarium for speaking for The Coca-Cola Company. TO has received an honorarium for speaking for The Coca-Cola Company. The authors reported no other potential conflicts of interest.

**Figure legends**

**Figure 1.** Proportion of children considered overweight or obese from ISCOLE study sites and their representative countries. Dark grey bars indicate data from ISCOLE participants; white bars represent country-level data. If no white bar, then country level data are not available. Where available, data are presented for both boys and girls. Data were analyzed as per BMI cut-points available in each country as follows. World Health Organization: Portugal, Colombia, Brazil; International Obesity Task Force: Canada, Australia; Center for Disease Control and Prevention: United States; other: United Kingdom (British 1990 growth reference[16]), China (China BMI criteria, overweight ≥19.4, obese ≥22.2).[43] Country level datasets included: U.K.: National Child Measurement Programme;[16] Portugal: Plataforma Contra a Obesidade;[44] Canada: Canadian Health Measures Survey;[45] U.S., National Health and Nutrition Examination Survey; Colombia: Encuesta Nacional de la Situación Nutricional; Brazil: Brazilian Institute of Geography and Statistics;[24] China: China Health and Nutrition Survey;[43] Australia: Australian National Children's Nutrition and Physical Activity Survey.[34] BMI: Body Mass Index. See Additional file 3 for additional study details for country level data.

**Figure 2.** Daily physical activity (steps per day) from ISCOLE study sites and their representative countries. Dark grey bars indicate data from ISCOLE participants; white bars represent country-level data. If no white bar, then country level data were not available. Where available, data are presented for both boys and girls. Horizontal black line represents mean steps per day for all ISCOLE participants; horizontal dashed line represents target of 12 000 steps per day recommended to meet current physical activity guidelines.[46] Data were included if it was collected via pedometer or accelerometer, and presented as sample mean. Country level datasets included: Finland: Physical Activity of School Aged Children;[47] United Kingdom: Millennium Cohort Study;[15] Canada: Canadian Health Measures Survey;[27] U.S.: National Health and Nutrition Examination Survey;[48] Australia:Australian National Children's Nutrition and Physical Activity Survey.[34] The Millennium Cohort Study also provided data for England: 10 147 steps per day compared to 9 982 steps per day in ISCOLE. See Additional file 4 for additional study details for country level data.

**Figure 3.** Proportion of children exceeding screen time guidelines (>2 hours per day) from ISCOLE sites and their representative countries. Dark grey bars indicate data from ISCOLE participants; white bars represent country-level data. If no white bar, then country level data were not available. Where available, data are presented for both boys and girls. Horizontal black like represents mean proportion of all ISCOLE participants who exceed screen time guidelines. Country level datasets included: Canada, Finland, the U.K., and the U.S.: Healthy Behaviors in School-aged Children;[3] South Africa: Time of Use survey;[22] Colombia: Instituto Colombiano de Bienestar Familiar (ICBF); China: China Health and Nutrition Survey;[49] Australia: Australian Bureau of Statistics.[35] See Additional file 5 for additional study details for country level data.

**Figure 4.** Proportion of girls (Panel A) and boys (Panel B) who self-reported that they engage in at least 60 minutes of moderate- to vigorous-intensity physical activity every day of the week. Dark grey bars indicate data from ISCOLE participants; white bars represent data that were adapted from the HBSC survey.[4] MVPA: moderate- to vigorous-intensity physical activity.

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Table 1: ISCOLE country characteristics

| Country | National population[a] | ISCOLE site location | Population of ISCOLE site location[b] | World bank classification[c] | Large and/or National study/studies |
|---|---|---|---|---|---|
| **Europe** | | | | | |
| Finland | 5 442 322 | Helsinki, Espoo, Vantaa | 1 060 701 | High-income | HBSC |
| United Kingdom | 63 705 000 | Bath, North East Somerset | 177 700 | High-income | ENERGY, HBSC[d], HELENA, IDEFICS, MCS |
| Portugal | 10 562 178 | Porto | 237 584 | High-income | EYHS[j], HBSC, |
| **Africa** | | | | | |
| Kenya | 44 354 000 | Nairobi | 3 138 369 | Low-income | None available |
| South Africa | 52 981 991 | Cape Town | 3 497 097 | Upper-middle-income | Time of Use survey |
| **The Americas** | | | | | |
| Canada | 35 158 304 | Ottawa | 883 391 | High-income | CHMS, HBSC |
| United States | 316 783 000 | Baton Rouge | 802 484 | High-income | HBSC, NHANES, YRBS |
| Colombia | 47 262 816 | Bogotá | 7 674 366 | Upper-middle-income | ENSIN |
| Brazil | 201 032 714 | Sao Caetano do Sul | 149 263 | Upper-middle-income | BIGS |
| **South Asia** | | | | | |
| India | 1 242 456 566 | Bangalore | 9 588 910 | Lower-middle-income | None available |
| **Western Pacific** | | | | | |
| China | 1 362 620 526 | Tianjin | 10 290 987 | Upper-middle-income | CNNS |
| Australia | 23 235 207 | Adelaide | 1 212 982 | High-income | AHS, ANCNPAS |

[a]Population estimate accessed October 2014. [b]Represents the population size of the city or general area where children were sampled. [c]World Bank classification represents. [d]Since the U.K. ISCOLE site was in England, the corresponding HBSC data was taken from HBSC England site.

AHS: Australian Health Survey; ANCNPAS: Australian National Children's Nutrition and Physical Activity Survey; BIGS: Brazilian Institute of Geography and Statistics; CNNS: China National Nutrition Survey; CHMS: Canadian Health Measures Survey; ENERGY: EuropeaN Energy balance Research to prevent excessive weight Gain among Youth; ENSIN: Encuesta Nacional de la Situación Nutricional (National Survey of Nutritional Status); IDEFICS: identification and prevention of dietary- and lifestyle induced health effects in children and infants; HBSC: Health Behavior in School-aged Children; HELENA: Healthy Lifestyle in Europe by Nutrition in Adolescents; MCS: Millennium Cohort Study; NHANES: National Health and Nutrition Examination Survey.

Table 2: ISCOLE participant characteristics

| Study site | Participants (*n*, % boys) | Age (years) (mean, SD) | Weight status (%)[a] | Combined annual household income[b] | Approximate equivalent in U.S. dollars[c] |
|---|---|---|---|---|---|
| **Europe** | | | | | |
| Finland | 536 (47.2%) | 10.0 (0.4) | Normal weight: 74.6<br>Overweight/obese: 23.7 | Less than 20 000€: 5.5%<br>80 000€ and above: 40.9% | $26 000: 5.5%<br>$104 000 and above: 40.9% |
| United Kingdom | 525 (45.1%) | 10.4 (0.5) | Normal weight: 68.5<br>Overweight/obese: 30.3 | Less than £10 000: 9.4%<br>£10 000 - £19 999: 17.3%<br>£90 000 and above: 8.1% | Less than $16 500: 9.4%<br>$16 500-$32 998: 17.3%<br>$148 500 and above: 8.1% |
| Portugal | 777 (46.1%) | 10.0 (0.3) | Normal weight: 52.5<br>Overweight/obese: 47.2 | Under €6 000: 20.5%<br>€6 000 - €11 999: 30.9%<br>€42 000 and above: 5.5% | Under $7 800: 20.5%<br>$7 800-15 599: 30.9%<br>$54 6000 and above: 5.5% |
| **Africa** | | | | | |
| Kenya | 563 (46.5%) | 9.8 (0.7) | Normal weight: 75.1<br>Overweight/obese: 21.1 | Less than Ksh. 121 980: 23.2%<br>Ksh 6 000 000 and above: 3.5% | Less than $1 342: 23.2%<br>$66 000 and above: 3.5% |
| South Africa | 550 (40.1%) | 9.8 (0.7) | Normal weight: 71.2<br>Overweight/obese: 26.4 | Less than R11 500: 47.8%<br>More than R500 000: 7.6% | Less than $1 081: 47.8%<br>$47 000 and above: 7.6% |
| **The Americas** | | | | | |
| Canada | 565 (42.2%) | 10.0 (0.4) | Normal weight: 68.7<br>Overweight/obese: 30.8 | Less than $14 999: 2.9%<br>$140 000 and above: 38.4% | Less than $13 799: 2.9%<br>$128 800 and above: 38.4% |
| United States | 651 (43.2%) | 9.5 (0.6) | Normal weight: 58.4<br>Overweight/obese: 41.3 | Less than $10 000: 20.4%<br>$140 000 and above: 21.6% | N/A |
| Colombia | 919 (49.4%) | 10.0 (0.6) | Normal weight: 75.7<br>Overweight/obese: 22.9 | $0-$1 200 000: 0.7%<br>$ 4 800 000 - $8 400 000: 29.4%<br>$36 000 000 and above: 8.8% | $0-$624: 0.7%<br>$2 496-$4 368: 29.4%<br>$18,720 and above: 8.8% |
| Brazil | 584 (49.1%) | 10.1 (0.5) | Normal weight: 52.8<br>Overweight/obese: 45.2 | Under R$6 540: 3.1%<br>R$6 540 - R$19 620: 35.1%<br>R$85 020 and above: 4.4% | Less than $2 943: 3.1%<br>$2 943-$8 829: 35.1%<br>$38 259 and above: 4.4% |
| **South Asia** | | | | | |
| India | 620 (47.1%) | 10.0 (0.6) | Normal weight: 61.5<br>Overweight/obese: 33.7 | Less than Rs 60 000: 2.8%<br>Rs720 000 – and above: 37.6% | Less than $1 020: 2.8%<br>$12 240 and above: 37.6% |
| **Western Pacific** | | | | | |
| China | 552 (53.1%) | 9.4 (0.5) | Normal weight: 56.3<br>Overweight/obese: 41.2 | Less than ¥20 000: 18.1%<br>¥20 000 - ¥39 999: 18.1%<br>¥150 000 and above: 10.4% | Less than $3 200: 18.1%<br>$3 200-$6 400: 18.1%<br>$24 000 and above: 10.4% |
| Australia | 528 (46.0%) | 10.3 (0.5) | Normal weight: 61.4<br>Overweight/obese: 37.9 | Less than $10 000: 2.1%<br>$70 000 to $89 999: 17.0%<br>$140 000 and above: 21.7% | Less than $9 300: 2.1%<br>$65 100-$83 699: 17.0%<br>$130 200 and above: 21.7% |

[a]Weight status defined by World Health Organization cut-points.[39] [b]Presented as percent of participants in the lowest, highest, and median income categories. If the median income category was also the lowest, or the highest, only two income categories are presented see Figure 5 for income distribution and Additional file 1 for additional information. [c]Currency conversion reflects rates from 2014.

**Figure 1.** Proportion of children considered overweight or obese from ISCOLE study sites and their representative countries. Dark grey bars indicate data from ISCOLE participants; white bars represent country-level data. If no white bar, then country level data are not available. Where available, data are presented for both boys and girls. Data were analyzed as per BMI cut-points available in each country as follows. World Health Organization: Portugal, Colombia, Brazil; International Obesity Task Force: Canada, Australia; Center for Disease Control and Prevention: United States; other: United Kingdom (British 1990 growth reference[16]), China (China BMI criteria, overweight ≥19.4, obese ≥22.2).[43] Country level datasets included: U.K.: National Child Measurement Programme;[16] Portugal: Plataforma Contra a Obesidade;[44] Canada: Canadian Health Measures Survey;[45] U.S., National Health and Nutrition Examination Survey; Colombia: Encuesta Nacional de la Situación Nutricional; Brazil: Brazilian Institute of Geography and Statistics;[24] China: China Health and Nutrition Survey;[43] Australia: Australian National Children's Nutrition and Physical Activity Survey.[34] BMI: Body Mass Index. See Additional file 3 for additional study details for country level data.
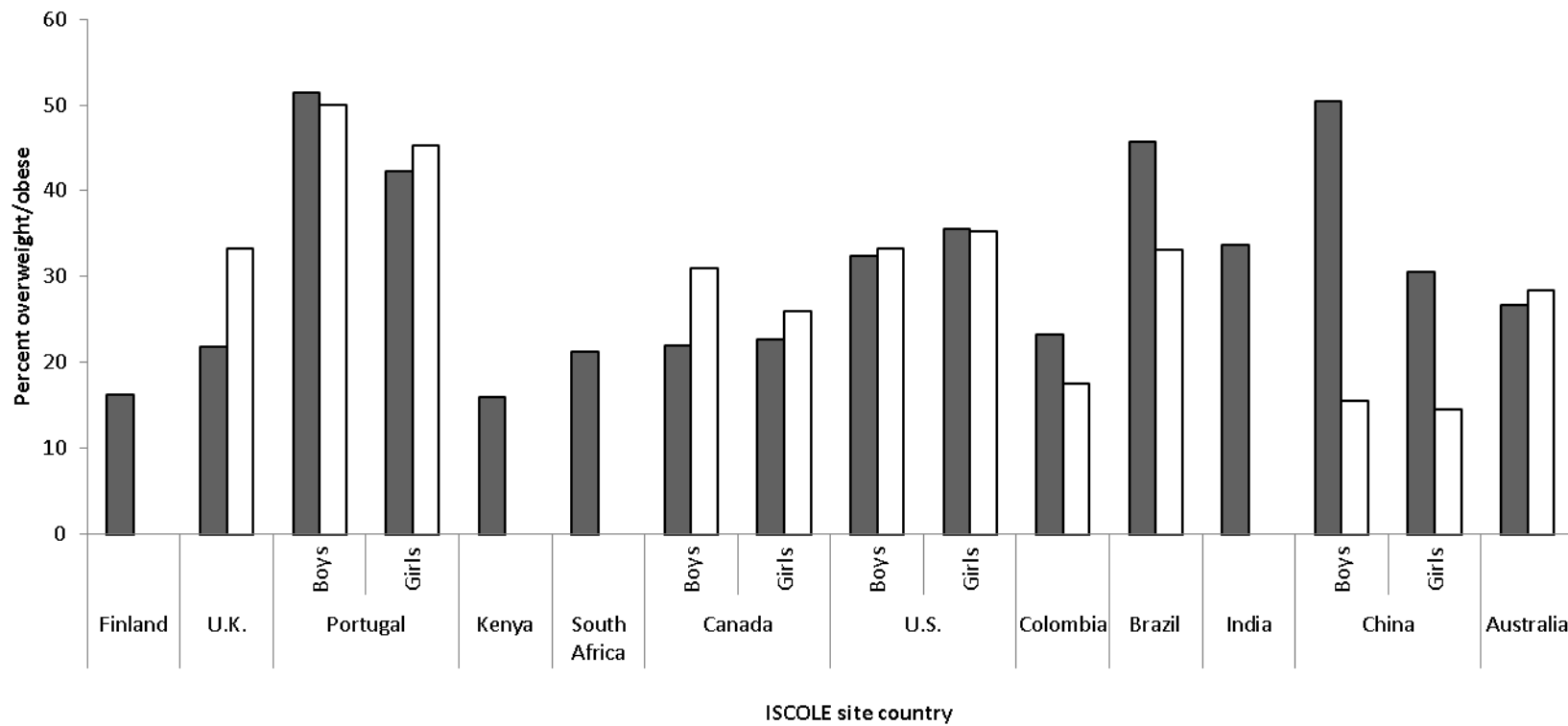
**Figure 2.** Daily physical activity (steps per day) from ISCOLE study sites and their representative countries. Dark grey bars indicate data from ISCOLE participants; white bars represent country-level data. If no white bar, then country level data were not available. Where available, data are presented for both boys and girls. Horizontal black line represents mean steps per day for all ISCOLE participants; horizontal dashed line represents target of 12 000 steps per day recommended to meet current physical activity guidelines.[46] Data were included if it was collected via pedometer or accelerometer, and presented as sample mean. Country level datasets included: Finland: Physical Activity of School Aged Children;[47] United Kingdom: Millennium Cohort Study;[15] Canada: Canadian Health Measures Survey;[27] U.S.: National Health and Nutrition Examination Survey;[48] Australia:Australian National Children's Nutrition and Physical Activity Survey.[34] The Millennium Cohort Study also provided data for England: 10 147 steps per day compared to 9982 steps per day in ISCOLE.See Additional file 4 for additional study details for country level data.
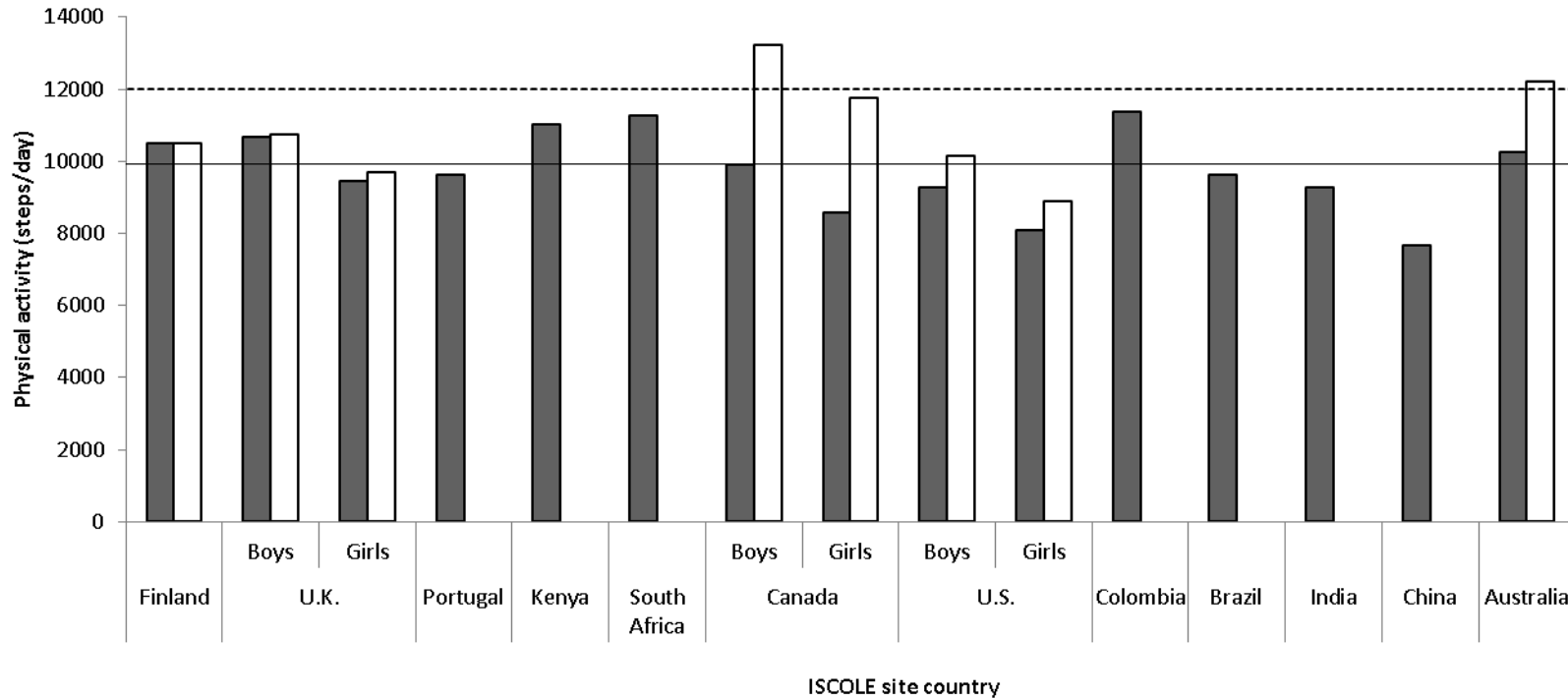
**Figure 3.** Proportion of children exceeding screen time guidelines (>2 hours per day) from ISCOLE sites and their representative countries. Dark grey bars indicate data from ISCOLE participants; white bars represent country-level data. If no white bar, then country level data were not available. Where available, data are presented for both boys and girls. Horizontal black like represents mean proportion of all ISCOLE participants who exceed screen time guidelines. Country level datasets included: Canada, Finland, the U.K., and the U.S.: Healthy Behaviors in School-aged Children;[3] South Africa: Time of Use survey;[22] Colombia: Instituto Colombiano de Bienestar Familiar (ICBF); China: China Health and Nutrition Survey;[49]Australia: Australian Bureau of Statistics.[35]See Additional file 5 for additional study details for country level data.
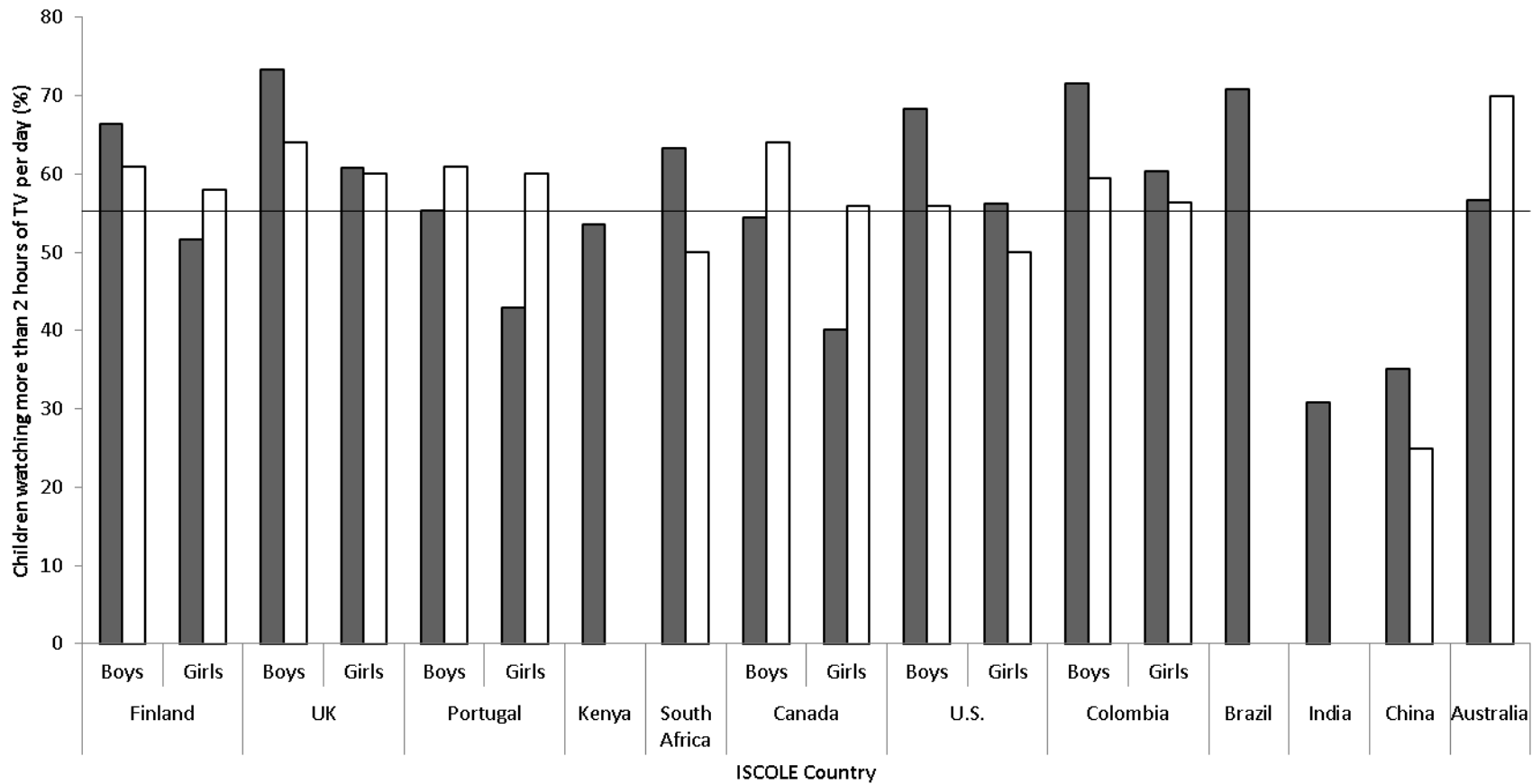
**Figure 4**. Proportion of girls (Panel A) and boys (Panel B) who self-reported that they engage in at least 60 minutes of moderate- to vigorous-intensity physical activity every day of the week. Dark grey bars indicate data from ISCOLE participants; white bars represent data that were adapted from the HBSC survey.[4] MVPA: moderate-to vigorous-intensity physical activity.