**Abstract**

**Background:** We assessed if school uniforms are associated with population-level gender inequalities in physical activity, and if associations differ by school level, country income, and assessment method.

**Methods:** An ecological study design was employed. We collected data about global uniform practices using an online survey. We searched for country-level estimates of school-aged youth meeting physical activity guidelines from international surveillance studies. Study selection was conducted in duplicate using a systematic process, and a random sample of all data was checked to ensure extraction and pooling processes were accurate. We calculated absolute and relative gender inequalities in physical activity for each country. Linear regression examined associations between country-level uniform practices (binary yes/no exposure variable) and country-level gender inequalities in physical activity guideline compliance (absolute and relative inequalities). We investigated moderation by school level, stratified analyses by income group and repeated primary analyses using device-measured data.

**Results:** Pooling data from 135 countries (n=1,089,852), we found no association between population uniform practices and gender inequalities in physical activity across all ages (absolute: β=-0.2; 95% CI:-1.7, 1.3, p=0.74; relative: β=0.1; -0.1, 0.2, p=0.51). Subgroup analysis suggested a positive association in primary school settings (absolute: β=4.3; -0.0, 8.6, p=0.05). Among high-income countries, absolute inequalities were significantly greater in countries with uniform practices (N=37) compared to those without (N=48) (9.1 (SD: 3.6) vs 7.8 percentage points (SD: 4.3)). Repeating analyses using device-measured data (n=32,130, N=24) did not alter our primary finding. From initial descriptive statistics, we found that in countries where a majority of schools (>50%) reportedly use uniforms, there was lower

compliance with physical activity guidelines among all genders (median: 16.0%, IQR: 13.2-19.9, N=103) compared to generally non-uniform countries (median: 19.5%, IQR: 16.4-23.5, N=32) (z=3.04, p=0.002).

**Conclusion:** School uniforms are associated with greater gender inequalities in physical activity in primary school settings and in high-income countries. Our population-level findings warrant testing using individual-level data across contexts.

## Introduction

The World Health Organisation (WHO) recommends children and adolescents aged 5-17 years engage in an average of 60 minutes of at least moderate-intensity physical activity per day across the week.[1] They also recommend vigorous-intensity aerobic activities, as well as muscle- and bone-strengthening activities, are incorporated at least three days per week. Sedentary time should be limited, particularly if that time is not for school or work purposes.[1] These recommendations are based on a large body of evidence, suggesting that young people need this amount (frequency, duration, intensity) and type (aerobic, muscle-strengthening, and bone-strengthening activities) of physical activity to meet their multiple physical, mental and well-being needs.[2]

Studies are increasingly conducted in countries worldwide to assess population levels of physical activity among young people (e.g., using a survey or a device-based measure).[3, 4] Surveillance studies, which typically focus on measuring young people's weekly moderate-to-vigorous intensity physical activity, play a crucial role in evaluating guideline compliance and hence the health status of young people. Findings from these studies indicate that many children and adolescents worldwide are not meeting the WHO physical activity guidelines.[5-9] While equalities in opportunities for individuals to be physically active vary within and between countries, gender disparities account for the largest proportion of observed global physical activity inequalities worldwide among both child and adolescent populations.[7-11] The individual and societal-level costs associated with physical inactivity and related gender inequalities are high.[12] Yet reasons why girls are less likely to meet physical activity guidelines than their male peers throughout childhood and adolescence remain poorly understood.

Gender inequalities in physical activity appear early in life, between the ages of two and six years,[3, 13, 14] a time when children typically enter education. Girls often report additional barriers to physical activity compared to boys in several settings in their lives, including in school settings.[15-17] School policies, defined as "organisational statements or rules that are intended to influence behaviour"[18] may play a role. However, review-level evidence indicates that existing studies primarily focus on school policies related to extra-curricular sports, Physical Education (PE) and recess;[19, 20] periods which only account for a small portion of the whole school day. Moreover, extra-curricular sports are not accessible to many students[21] and the physical activity students typically gain from PE class typically represents a fraction of their total recommended amount of moderate-to-vigorous intensity physical activity.[22, 23] School policies and their association with gender inequalities in physical activity beyond high-income countries are also understudied.[20]

School uniforms are common in many primary and secondary school settings globally.[24] While some researchers have explored their relationship with other outcomes[25-30] (e.g., academic achievement[27, 31] and social behaviour[28]), finding no or inconsistent correlations, studies examining associations with gender inequalities in physical activity are limited. Previous researchers, who explored UK adolescent girls' experiences of physical activity at school through the lens of comfort theory,[32] found that female participants perceived their PE uniform as a barrier to physical activity.[17] They reported the design and fabric compromised their privacy, negatively impacting their sense of confidence and willingness to engage in specific PE movements (e.g., cartwheeling).[17] Whole–day school uniforms, for which items are often also segregated by gender, could similarly influence students' physical activity behaviour. These uniforms are typically worn for longer periods than PE attire and during

times when young people accrue a greater portion of their daily physical activity (e.g., during recess,[33] school travel[34, 35]). Observational research studies have found that some girls perceive their whole-day uniforms as a barrier to break time play[36, 37] and school active travel.[38, 39] Experimental evidence also suggests primary school-aged girls are more active and less sedentary on days when they are not wearing their regular uniform.[40, 41] However, studies come from a limited number of high-income countries, report on small sample sizes, and focus solely on school-time physical activity. Associations between uniforms and total weekly physical activity, which is most strongly associated with health and educational benefits,[2] have not been explored.

We, therefore, aimed to use population-level data for all variables to determine associations between school uniforms and gender inequalities in physical activity, using country-level compliance with the WHO moderate-to-vigorous intensity physical activity guidelines as our outcome. We also assessed whether associations differ by school level, country income classification, and physical activity assessment method.

## Methods

This study is reported in accordance with the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) statement for cross-sectional studies.[42]

### Study design and data sources

We employed a cross-sectional design using published data on the proportion of children and adolescents meeting physical activity guidelines as the outcome. We then conducted an online survey to determine the use of school uniform practices among countries with sex-stratified data on population-level estimates of physical activity guideline compliance. Based on data from the World Bank, we categorised children aged 6-11.99 years as primary school age and adolescents aged 12-17.99 years as secondary school age.[43] Further study measures are detailed below. Operational definitions adopted for this study are outlined in Supplementary File 1.

### Physical activity data

*Identification of eligible studies*

We searched eight international surveillance initiatives for studies reporting population estimates of the percentage of boys and girls aged 6-17 years meeting physical activity guidelines.[44] Studies had to report on the: i) country from which participants were sampled, ii) age/age range of participants, iii) year(s) of data collection, iv) method used to assess physical activity (survey/device-measured), and v) guideline/reference used to estimate total physical activity (e.g., compliance with 2020 WHO guidelines).[1]

Thereafter, we applied inclusion and exclusion criteria to screen out studies not reporting data that addressed our research questions. Studies had to report the percentages of children and adolescents meeting physical activity guidelines by gender or provide sufficient information for this to be calculated. Participants had to be sampled from the general population. In instances where study authors reported device-measured data and did not publish guideline compliance by gender, we contacted them and requested this data. Following the aforementioned screening exercise, we still found that few studies reported on device-measured data. We therefore contacted the authors of the largest international surveillance initiative of device-measured physical activity[45] and requested unpublished data on guideline compliance by gender.

*Study selection*

If multiple studies reported on the same country and school-age category (e.g., three studies reporting on primary school-aged children in Germany), we selected only one study for inclusion. We used a hierarchy to prioritise study inclusion at the country level (see Supplementary File 2). All study selection decisions were conducted independently by two members of the team. Disagreements were resolved via discussion by referring back to primary sources. Studies not selected for inclusion are listed in Supplementary File 3 with reason codes.

*Data coding*

If single studies reported multiple prevalence estimates for different age groups, we combined these into school age categories of interest using formulae outlined in the Cochrane Handbook.[46] We used averages if sample sizes were not reported. If data on guideline

compliance by gender crossed our school age categories of interest (e.g., participants aged 8-12), samples were categorised as 'primary' or 'secondary' based on study participants' reported median age. An exception was the 'Health Behaviour in School-aged Children' study, in which study participants aged 11 were categorised as 'primary' or 'secondary' based on the mean secondary school starting age in that country.[43]

**School uniform practices**

We conducted an online survey to determine school uniform practices in countries with eligible physical activity data. To minimise error, two respondents per country were sought. We obtained survey responses through various channels, including social media advertisements, international societies and university mailing lists, inquiries made to embassies, high commissions, and consulates, and personal and professional contacts of the researchers. Survey participants were asked i) whether the majority (>50%) of primary and secondary schools in that country use uniforms or not (response options: Yes/No/Don't know) and ii) whether practices had significantly changed in the past decade. All data was collected between April-September 2022 using Qualtrics. Survey questions are outlined in Supplementary File 4. Where more than two responses were available for a given country and responses differed, the response supported by the majority was taken. Single responses were also accepted. Where exactly two responses were available and responses differed, data was coded as missing. Where data was unavailable or we solely received 'Don't know' responses, data was also coded as missing.

**Income classification**

Countries and regions were assigned income classifications based on groupings calculated by the World Bank.[47] We used income classifications from the year in which the largest proportion of physical activity data were collected or projected;[5] 2016.

**Data extraction and checking**

All data extraction was conducted by one member of the team. A random sample (10%) of the combined dataset (i.e., with population-level physical activity compliance estimates, uniform survey data, income classifications etc.) was independently checked by a second member to assess the accuracy of the extraction and pooling process (inter-rater agreement = 94.8%). In addition, all data extracted from physical activity surveillance studies reporting on secondary sources (i.e., the Global Matrix Study)[6] was checked by one member of the team against primary study sources where available.

**Statistical analysis**

We calculated absolute and relative gender inequalities in physical activity for each country with corresponding physical activity and school uniform data. Absolute inequalities were calculated by subtracting the percentage of girls meeting physical activity guidelines from the percentage of boys meeting physical activity guidelines. Relative inequalities were calculated by dividing the percentage of boys meeting physical activity guidelines by the percentage of girls meeting physical activity guidelines. Descriptive statistics were calculated for categorical and continuous variables. Means and standard deviations (SDs), or medians and interquartile ranges (IQR), are reported based on the distribution of physical activity outcomes. Mann-Whitney U tests were performed to compare median values between independent groups when the assumptions of parametric tests were not met.

Linear regression was used to explore associations between country-level uniform practices (binary yes/no exposure variable) and country-level gender inequalities in self-reported physical activity (absolute and relative inequalities, measured in percentage points and ratio respectively). We obtained cluster-robust standard errors using the 'vce (cluster clustvar)' Stata command to account for instances where data was available for both primary and secondary school settings in a single country. All models were checked for assumptions necessary for linear regressions (residual and Q-Q plots). A set of pre-planned models were run with interaction terms between the exposure (country-level uniform practices) and the following moderators: school level (primary vs secondary) and income classification grouping**.** Countries/regions with missing data on the moderators were excluded from interaction analyses. The majority of countries with a low, lower-middle or upper-middle-income classification were reported to use uniforms, precluding meaningful interaction analyses. We therefore present stratified summary statistics. To assess whether associations were affected by physical activity assessment method, we repeated primary analyses using device-measured data**.** For all analyses, Stata v.16 was used and the level of statistical significance was set at an alpha level of 5% (two-tailed).

## Results

### Characteristics of countries included

Data on both physical activity and uniform practices was available for 135 countries and regions. See Supplementary File 5 for a flow chart showing data availability, selection, and inclusion at each stage. Table 1 summarises the sample characteristics of all countries represented by physical activity assessment method. Here we focus on our primary outcome of interest: self-report measured physical activity. While countries from all income grouping classifications were represented, a higher proportion of high-income countries was represented (67.8% of all countries with a high-income classification in 2016 were included (N=78 countries), 62.5% of countries with an upper-middle income classification (N=56), 54.7% of countries with a lower-middle income classification (N=53), and 25.8% of countries with a low income classification (N=31)).

Table 1. Sample characteristics of countries and regions represented (N=135), by physical activity assessment method

| | Self-report[a] N=135 | | Device-measured[b] N=24 | |
|---|---|---|---|---|
| Countries/regions represented | | | | |
| **Income classification[c]** | | | | |
| Low | 9 | (6.2) | 1 | (4.2) |
| Lower-middle | 29 | (22.3) | - | - |
| Upper-middle | 36 | (27.7) | 1 | (4.2) |
| High | 56 | (43.1) | 22 | (91.7) |
| **Uniform practices[d]** | | | | |
| *Prevalent in >50% of primary schools* | | | | |
| Yes | 104 | (77.0) | 7 | (29.2) |
| No | 31 | (23.0) | 17 | (70.8) |
| *Prevalent in >50% of secondary schools* | | | | |
| Yes | 103 | (76.3) | 7 | (29.2) |
| No | 32 | (23.7) | 17 | (70.8) |

| | | | | |
|---|---|---|---|---|
| **Physical activity data available, N (%)** | | | | |
| Primary school age only | 2 | (1.5) | 4 | (16.7) |
| Secondary school age only | 98 | (73.1) | 5 | (20.8) |
| Both school age settings | 35 | (26.1) | 15 | (62.5) |

[a] Countries/regions represented with self-report physical activity data, [b] Countries/regions represented with device-measured physical activity data, [c] 2016 World Bank Income classification groupings based on gross national income per capita, no classification grouping assigned to five regions included (3.8%); [d] Based on consensus from uniform survey data (n=391 respondents)

**School uniform practices**

In a majority of countries, school uniform practices were reported as common in primary (77.0%) and secondary (76.3%) school settings. A small number of countries reported changes to uniform practices in the previous 10 years. Changes were reported in primary school settings in 13 countries (9.6%) and in secondary school settings in eight countries (5.9%). See Supplementary File 6 for further information.

**Physical activity studies included**

Sample characteristics of physical activity studies included are summarised in Table 2. Population-level estimates are based on self-reported data from 1,089,852 children and adolescents (median sample size per country: 3,427). Studies largely reported on secondary school-aged students (78.2%).

Table 2. Sample characteristics of physical activity studies included (self-report and device-measured)

| Physical activity studies N=209 | Self-report N=170 | | Device-measured N=39 | |
|---|---|---|---|---|
| **Sample characteristics** | | | | |
| Total N[a], % female[b] | 1,089,852 | (51.4) | 32,130 | (51.3) |
| Study sample median, IQR | 2,892 | 1,710-4,686 | 516 | 327-1,111 |
| Country sample median[c], IQR | 3,427 | 2,087-5,700 | 1,003 | 457-1,583 |

| | | | | |
|---|---|---|---|---|
| **School level represented** | | | | |
| Primary school age (6<12 years), % | 37 | (21.8) | 19 | (48.7) |
| Secondary school age (12<18 years), % | 133 | (78.2) | 20 | (51.3) |
| **Year(s) of data collection[d], range** | 2005-2018 | | 1997-2018 | |
| **% meeting guidelines, median (range)** | | | | |
| Primary school-aged boys | 26.6 | (5.8-80.0) | 48.0 | (12.5-96.3) |
| Primary school-aged girls | 20.0 | (2.8-66.2) | 21.0 | (6.0-87.0) |
| Secondary school-aged boys | 19.6 | (7.2-64.1) | 35.0 | (23.0-69.8) |
| Secondary school-aged girls | 12.3 | (5.3-55.0) | 11.8 | (2.0-52.1) |

[a] Data missing on total sample size from three self-report studies (1.8%) and two device-measured studies (5.1%), [b] Data missing about total sample size or gender-specific N/% from 65 self-report studies (48.1%) and eight device-measured studies (20.5%), [c] Where uniform and physical activity data available for both school age settings, [d] Indicates year(s) of physical activity data collection (or projection)

**Association between school uniform practices and gender inequalities in physical activity**

Pooled self-reported data showed that guideline compliance was significantly lower in countries with uniform practices (N=103) (median: 16.0%, IQR: 13.2-19.9) compared to those without (N=32) (median: 19.5%, IQR: 16.4-23.5) (z=3.04, p=0.002, Mann-Whitney U test).

Across all countries, the mean difference between the percentage of boys and girls meeting physical activity guidelines (absolute inequalities) across all ages was 7.6 percentage points (SD: 4.8). Boys were 1.5 (SD: 0.4) times more likely to meet physical activity guidelines than girls (relative inequalities). Linear regression showed no association between country-level uniform practices and population gender inequalities in physical activity (absolute inequalities: β=-0.2, 95% CI: -1.7, 1.3; relative inequalities: β=0.1, 95% CI: -0.1, 0.2) (see Table 3).

**Differences by school level, income classification or assessment method**

We found a significant interaction with school level (β=5.9, 95% CI: 0.8, 11.0), suggesting uniform use may be associated with greater gender inequalities in physical activity in primary school settings compared to secondary school settings. Subsequent stratified analyses suggested that, among primary school-aged children, absolute gender inequalities in physical activity guideline compliance were 4.3 percentage points higher in countries with uniform practices compared to those without (95% CI: -0.0, 8.6) (see Table 3).

In countries with a high-income classification, absolute physical activity inequalities were greater in countries with uniform practices (N=37) compared to those without (N=48) (9.1 (SD: 3.6) vs 7.8 percentage points (SD: 4.3) (z=-2.37, p<0.02, Mann-Whitney U test). Among countries with a low, lower-middle or upper-middle-income classification, differences in absolute physical activity inequalities between countries with uniform practices (N=74) compared to those without (N=6) were negligible (6.8 (SD: 5.6) vs. 6.7 percentage points (SD: 2.6)).

Using device-measured physical activity guideline compliance as the outcome did not alter our primary findings; we found no association between country-level uniform practices and population gender inequalities across both school levels (absolute inequalities: β=-2.2 percentage points, 95% CI: -10.8, 6.4; relative inequalities: β=-1.1, 95% CI: -2.3, 0.1) (see Table 3).

Table 3: Results of regression analyses, exploring associations between country-level uniform practices and population gender inequalities in physical activity guideline compliance

| | | Absolute inequalities | | Relative inequalities | |
|---|---|---|---|---|---|
| | **N**[a] | **β** | **95% CI** | **β** | **95% CI** |
| **Primary research question** | | | | | |
| *Uniform use (yes/no)* | 135 | -0.2 | [-1.7, 1.3] | 0.1 | [-0.1, 0.2] |
| **Secondary research questions** | | | | | |
| *School level* | | | | | |
| Interaction term | | | | | |
| Uniform use*school level (ref: secondary) | 135 | 5.9 | [0.8, 11.0] | 0.3 | [-0.1, 0.7] |
| *Stratified analysis* | | | | | |
| Primary school age | 37 | 4.3 | [-0.0, 8.6] | 0.2 | [-0.1, 0.6] |
| Secondary school age | 133 | -1.6 | [-3.3, 0.6] | -0.1 | [-0.3, 0.1] |
| *Uniform use (yes/no) (device-measured)* | 24 | -2.2 | [-10.8, 6.4] | -1.08 | [-2.3, 0.1] |

290 [a] Number of countries/regions represented in model, β Beta coefficient, CI Confidence interval
291

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## Discussion

Few studies have examined whether school uniforms are associated with gender inequalities in physical activity or examined evidence beyond high-income country contexts. Examining pooled data from 135 countries, we found evidence that the common use of school uniforms is associated with lower compliance with international physical activity guidelines among school-aged children and adolescents. We found no association between country-level school uniform practices and gender inequalities in physical activity across all school levels, but evidence showed an association with greater gender inequalities in primary school settings. We also found preliminary evidence that associations between uniforms and gender inequalities in physical activity may be greater in high-income countries than in countries with other income classifications.

Our finding that uniforms are associated with lower compliance with physical activity guidelines regardless of gender is a novel contribution to the literature. This was not a pre-defined research question, but its emergence from initial descriptive statistics potentially highlights a crucial gap. To date, boys have been reported not to perceive uniforms as a barrier to their physical activity,[17, 37-39] or have been excluded from studies prompting participants to consider their role.[36] Previous quantitative evidence suggests boys accumulate more vigorous-intensity physical activity[40] and are less sedentary[41] during recess when not wearing their regular uniform, but these studies did not report an association with total school-time physical activity. We examined associations between uniforms and physical activity guideline compliance across the week. Our findings suggest associations between uniforms and physical activity beyond school hours and across genders may have been overlooked and underestimated.

317

318 Our findings indicate uniforms are associated with greater gender inequalities in physical
319 activity at the population level in primary but not secondary school settings. These age-based
320 findings may be explained by greater gender inequalities among younger children,[3] lower
321 overall physical activity levels among secondary school-aged adolescents, and marked
322 differences in how and where children and adolescents accrue their physical activity. For
323 example, primary school-aged children accrue more of their physical activity from sporadic
324 movements throughout the day, during which they may be wearing their uniform, whereas
325 adolescents accrue a greater proportion of their total physical activity from structured
326 activities (e.g., Physical Education, sport),[48] during which they may be encouraged or required
327 to change. Primary school-aged children may also gain a larger proportion of their total
328 physical activity from active and risky play (e.g., hanging, balancing from heights, jumping).
329 This may present greater challenges for girls if they are required or expected to wear skirts
330 and dresses as part of their school uniform. Our findings are supported by experimental
331 research[40, 41] but limited by power. [17] Broader socio-cultural factors may also be driving some
332 of the relationship. For example, uniforms are a legacy of colonialism in many countries
333 represented in this study. Hence, they may serve as a proxy measure for some other shared
334 cultural practice, value, or school policy, associated with gender inequalities in physical
335 activity. Further research is therefore recommended on what may be driving the relationship
336 between school uniforms and physical activity among primary school-aged children.

337

338 This is the first known study to examine associations between school uniforms and global
339 gender inequalities in physical activity. Studies in which girls report uniforms as a barrier to
340 physical activity have largely come from a limited number of high-income countries (i.e.,

Australia[36, 37, 40, 41] and New Zealand[38, 39]). Our findings suggest associations between uniforms and gender inequalities in physical activity may be greater in high-income countries than in countries with other income classifications. This may reflect differences in gender-specific barriers and facilitators to physical activity across contexts. We grouped countries with a low, lower-middle, or upper-middle income classification as there was limited variation in uniform practices. Our findings should therefore be interpreted with caution as this grouping may mask significant differences between countries with the same income classification.[49]

**Strengths and limitations**

This study addresses calls to examine gender inequalities in physical activity among young people.[50] We pooled a large number of studies from international physical activity surveillance initiatives and used a rigorous method to select the best data to answer our research questions. We also report on unpublished data from the most comprehensive, high quality and large-scale surveillance initiative of harmonised device-measured physical activity to overcome data availability limitations. Study selection was conducted in duplicate using a systematic process, and a random sample of all data was checked to ensure extraction and pooling processes were accurate. All data reported in surveillance studies using secondary sources was cross-checked. Finally, we report novel country-level data about the prevalence of uniform practices; this can be used in future research.

We acknowledge that causation cannot be inferred as we aimed to maximise geographic coverage, and international surveillance initiatives predominantly employ cross-sectional designs. Countries with a high-income classification are over-represented. The greatest burden of disease associated with physical inactivity is felt in middle-income countries,[51] and a rapidly increasing proportion of the global child and adolescent population are not based in

high-income countries.[52] Surveillance initiatives also use measures of physical activity that have solely been tested in a small number of high-income countries; their validity, reliability, and cultural appropriateness beyond these contexts remain unknown.[53] Our findings hence may reflect differential bias in the measures used. We solely included studies reporting on children and adolescents sampled from the general population. This may have led to biased guideline compliance estimates as many subgroups were inadvertently excluded (e.g., children and adolescents with additional health and educational needs). We sought two uniform survey participants per country to minimise error and there was a high level of within-country agreement. However, the survey was only offered in English, which may have introduced response bias. We also used a binary variable to assess majority uniform practices at the country level; our results may underestimate associations in contexts with significant within-country variability. We were unable to stratify our analysis by socio-economic position but acknowledge evidence of socio-economic inequalities in physical activity within genders, particularly among primary school-aged children.[21] As evidence suggests country-level measures of gender inequality (e.g., Gini coefficient) are not globally positively associated with gender inequalities in physical activity,[54] we did not include them as covariates in our analyses. Wider country/regional-level factors, including climate, were also not included based on a similar lack of evidence.

**Future studies**

Given the costs of physical inactivity,[12] and data to suggest over 75% of the 135 countries represented in this study reportedly employ uniforms across primary and secondary school settings, our findings warrant further investigation. Student-level data is needed to explore the associations we identified in different contexts. While small-scale studies provide support

for our findings,[40, 41] the generalisability of our findings may be subject to biases associated with population-level studies, including ecological fallacy.[55] Future studies should assess specific features (e.g., clothing design and fabric/footwear) that facilitate or restrict physical activity. A dose-response association analysis is also recommended. Mechanisms of action underlying the relationship identified between school uniforms and gender inequalities in physical activity among primary school-age children should be explored; the limited number of known qualitative[17] and mixed-methods studies have focused on PE uniforms and physical activity behaviours among UK female adolescents (e.g., considering their socio-cultural impacts).[56] Gender minority groups also require greater attention. Future studies could address this research gap as changes are made to the binary measures currently used in most physical activity surveillance studies. Finally, associations between school policies and other components of the WHO guidelines (e.g., muscle-strengthening activities)[1] warrant investigation as they are increasingly measured in population surveillance studies.

## Conclusions

Regular physical activity is important for all young people, regardless of their gender, cultural background, or socioeconomic status.[1] Though educational settings represent a potential venue to promote population health, our findings suggest school uniform policies, common in many countries, may be restricting students' physical activity within and beyond the school day. Future studies should include student-level measures of uniform wear time and physical activity intensity across the week to enable a better assessment of the influence uniforms have on child and adolescent health.

## Data availability

Country-level data about uniform practices is reported in Supplementary File 6. The majority of physical activity data we analysed is publicly available. Further details are provided in Supplementary File 7. Device-measured data can be made available to researchers upon request; please email the corresponding author.

## Contributors

MR conceived the study, drafted the protocol, screened all studies for selection, extracted all data, conducted analyses and drafted the manuscript. EvS conceived the study, drafted the protocol, and advised on analyses. LR screened all studies for selection, checked a random sample of extracted data, cross-checked data from surveillance studies reporting on secondary sources against original studies where available, and advised on analyses. All authors contributed to the revision of the final paper, have approved the manuscript and provided consent for publication.

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## Declaration of interests

The authors declare no competing interests.

## References


1. Bull FC, Al-Ansari SS, Biddle S, et al. World health organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine* 2020;**54**:1451-62.
2. Chaput J-P, Willumsen J, Bull F, et al. 2020 who guidelines on physical activity and sedentary behaviour for children and adolescents aged 5–17 years: Summary of the evidence. *International Journal of Behavioral Nutrition and Physical Activity* 2020;**17**:141.
3. Cooper AR, Goodman A, Page AS, et al. Objectively measured physical activity and sedentary time in youth: The international children's accelerometry database (icad). *International journal of behavioral nutrition and physical activity* 2015;**12**:1-10.
4. Aubert S, Barnes JD, Demchenko I, et al. Global matrix 4.0 physical activity report card grades for children and adolescents: Results and analyses from 57 countries. *Journal of Physical Activity and Health* 2022;**19**:700-28.
5. Guthold R, Stevens GA, Riley LM, Bull FC. Global trends in insufficient physical activity among adolescents: A pooled analysis of 298 population-based surveys with 1·6 million participants. *The Lancet Child & Adolescent Health* 2020;**4**:23-35.
6. Aubert S, Barnes JD, Abdeta C, et al. Global matrix 3.0 physical activity report card grades for children and youth: Results and analysis from 49 countries. *Journal of Physical Activity and Health* 2018;**15**:S251-S73.
7. Bennie JA, Smith JJ, Qian W, Leatherdale ST, Faulkner G. Longitudinal trends and predictors of muscle-strengthening activity guideline adherence among canadian youths. *Journal of Science and Medicine in Sport* 2022;**25**:230-4.
8. Smith JJ, Diallo TMO, Bennie JA, Tomkinson GR, Lubans DR. Factors associated with adherence to the muscle-strengthening activity guideline among adolescents. *Psychology of Sport and Exercise* 2020;**51**:101747.
9. Prince SA, Roberts KC, Melvin A, Butler GP, Thompson W. Gender and education differences in sedentary behaviour in canada: An analysis of national cross-sectional surveys. *BMC Public Health* 2020;**20**:1170.
10. Bann D, Scholes S, Fluharty M, Shure N. Adolescents' physical activity: Cross-national comparisons of levels, distributions and disparities across 52 countries. *International Journal of Behavioral Nutrition and Physical Activity* 2019;**16**:141.
11. Reilly JJ, Barnes J, Gonzalez S, et al. Recent secular trends in child and adolescent physical activity and sedentary behavior internationally: Analyses of active healthy kids global alliance global matrices 1.0 to 4.0. *Journal of Physical Activity and Health* 2022;**19**:729-36.
12. Santos AC, Willumsen J, Meheus F, Ilbawi A, Bull FC. The cost of inaction on physical inactivity to public health-care systems: A population-attributable fraction analysis. *The Lancet Global Health* 2023;**11**:e32-e9.
13. Schmutz EA, Haile SR, Leeger-Aschmann CS, et al. Physical activity and sedentary behavior in preschoolers: A longitudinal assessment of trajectories and determinants. *international journal of behavioral nutrition and physical activity* 2018;**15**:1-12.
14. Farooq A, Martin A, Janssen X, et al. Longitudinal changes in moderate-to-vigorous-intensity physical activity in children and adolescents: A systematic review and meta-analysis. *Obesity Reviews* 2020;**21**:e12953.
15. Duffey K, Barbosa A, Whiting S, et al. Barriers and facilitators of physical activity participation in adolescent girls: A systematic review of systematic reviews. *Front Public Health* 2021;**9**:743935.
16. Jerebine A, Fitton-Davies K, Lander N, Eyre ELJ, Duncan MJ, Barnett LM. "All the fun stuff, the teachers say, 'that's dangerous!'" hearing from children on safety and risk in active play in schools: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity* 2022;**19**:72.

17. O'Reilly M, Wiltshire G, Kiyimba N, Harrington D. "Is everybody comfortable?"#xd; thinking through co-design approaches to better support girls' physical activity in schools. *Qualitative Research in Sport, Exercise and Health* 2023;**15**:248-63.
18. Sallis J, Bauman A, Pratt M. Environmental and policy interventions to promote physical activityaathis work was prepared for the ciar conference on physical activity promotion: An acsm specialty conference. *American Journal of Preventive Medicine* 1998;**15**:379-97.
19. Woods CB, Volf K, Kelly L, et al. The evidence for the impact of policy on physical activity outcomes within the school setting: A systematic review. *Journal of Sport and Health Science* 2021;**10**:263-76.
20. Stylianou M, Woodforde J, Duncombe S, Kolbe-Alexander T, Gomersall S. School physical activity policies and associations with physical activity practices and behaviours: A systematic review of the literature. *Health & Place* 2022;**73**:102705.
21. Owen KB, Nau T, Reece LJ, et al. Fair play? Participation equity in organised sport and physical activity among children and adolescents in high income countries: A systematic review and meta-analysis. *Int J Behav Nutr Phys Act* 2022;**19**:27.
22. Ikeda E, Guagliano JM, Atkin AJ, et al. Cross-sectional and longitudinal associations of active travel, organised sport and physical education with accelerometer-assessed moderate-to-vigorous physical activity in young people: The international children's accelerometry database. *International Journal of Behavioral Nutrition and Physical Activity* 2022;**19**:41.
23. Truelove S, Bruijns BA, Johnson AM, Gilliland J, Tucker P. A meta-analysis of children's activity during physical education lessons. *Health Behavior and Policy Review* 2020;**7**:292-313.
24. Baumann C, Krskova H. School discipline, school uniforms and academic performance. *International Journal of Educational Management* 2016;**30**:1003-29.
25. Valdebenito S, Eisner M, Farrington DP, Ttofi MM, Sutherland A. School-based interventions for reducing disciplinary school exclusion: A systematic review. *Campbell Systematic Reviews* 2018;**14**:i-216.
26. Shanks R, McKinney SJ. Cost and affordability of school uniform and child poverty. *Scottish Educational Review* 2022;**54**:26-48.
27. Gentile E, Imberman SA. Dressed for success? The effect of school uniforms on student achievement and behavior. *Journal of Urban Economics* 2012;**71**:1-17.
28. Ansari A, Shepard M, Gottfried MA. School uniforms and student behavior: Is there a link? *Early Childhood Research Quarterly* 2022;**58**:278-86.
29. Evans DK, Ngatia M. School uniforms, short-run participation, and long-run outcomes: Evidence from kenya. *The World Bank Economic Review* 2020;**35**:705-19.
30. Cristi-Montero C, Martínez-Flores R, Porras F, et al. A comparative study between traditional and sports school uniforms on cardiorespiratory and muscular fitness and waist-height-to-ratio in adolescents. *Front Public Health* 2023;**11**:1213403.
31. Cristi-Montero C, Solis-Urra P, Sanchez-Martinez J, et al. Which one? A comparative study of traditional and sports uniforms on academic achievement, cognitive performance, playtime, bullying, and discrimination in adolescents: The cogni-action project. *Frontiers in public health* 2022;**10**:2608.
32. Boudiab LD, Kolcaba K. Comfort theory. *Advances in Nursing Science* 2015;**38**:270-8.
33. Clevenger KA, McKee KL, McNarry MA, Mackintosh KA, Berrigan D. Association of recess provision with accelerometer-measured physical activity and sedentary time in a representative sample of 6- to 11-year-old children in the united states. *Pediatric Exercise Science* 2023:1-8.
34. Khan A, Mandic S, Uddin R. Association of active school commuting with physical activity and sedentary behaviour among adolescents: A global perspective from 80 countries. *Journal of Science and Medicine in Sport* 2021;**24**:567-72.

35. Campos-Garzón P, Sevil-Serrano J, García-Hermoso A, Chillón P, Barranco-Ruiz Y. Contribution of active commuting to and from school to device-measured physical activity levels in young people: A systematic review and meta-analysis. *Scandinavian Journal of Medicine & Science in Sports* 2023;**33**:2110-24.
36. Watson A, Eliott J, Mehta K. Perceived barriers and facilitators to participation in physical activity during the school lunch break for girls aged 12–13 years. *European Physical Education Review* 2015;**21**:257-71.
37. Stanley RM, Boshoff K, Dollman J. Voices in the playground: A qualitative exploration of the barriers and facilitators of lunchtime play. *Journal of Science and Medicine in Sport* 2012;**15**:44-51.
38. Hopkins D, Mandic S. Perceptions of cycling among high school students and their parents. *International Journal of Sustainable Transportation* 2017;**11**:342-56.
39. Ward AL, Freeman C, McGee R. The influence of transport on well-being among teenagers: A photovoice project in new zealand. *Journal of Transport & Health* 2015;**2**:414-22.
40. Norrish H, Farringdon F, Bulsara M, Hands B. The effect of school uniform on incidental physical activity among 10-year-old children. *Asia-Pacific Journal of Health, Sport and Physical Education* 2012;**3**:51-63.
41. Nathan N, McCarthy N, Hope K, et al. The impact of school uniforms on primary school student's physical activity at school: Outcomes of a cluster randomized controlled trial. *International Journal of Behavioral Nutrition and Physical Activity* 2021;**18**:17.
42. Erik von Elm M, Douglas G. Altman, Matthias Egger, Stuart J. Pocock, Peter C. Gøtzsche, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (strobe) statement: Guidelines for reporting observational studies. *Annals of Internal Medicine* 2007;**147**:573-7.
43. The World Bank. *Education statistics - all indicators*; Available from: https://databank.worldbank.org/indicator/SE.TER.ENRL?id=c755d342&report_name=EdStats_Indicators_Report&populartype=series. [Accessed 08 December 2022].
44. Aubert S, Brazo-Sayavera J, González SA, et al. Global prevalence of physical activity for children and adolescents; inconsistencies, research gaps, and recommendations: A narrative review. *International Journal of Behavioral Nutrition and Physical Activity* 2021;**18**:81.
45. Steene-Johannessen J, Hansen BH, Dalene KE, et al. Variations in accelerometry measured physical activity and sedentary time across europe – harmonized analyses of 47,497 children and adolescents. *International Journal of Behavioral Nutrition and Physical Activity* 2020;**17**:38.
46. Higgins JP, Li T, Deeks JJ. Choosing effect measures and computing estimates of effect. *Cochrane handbook for systematic reviews of interventions*. 2019, p. 143-76.
47. The World Bank. *Atlas method - detailed methodology.*; 2016. Available from: https://datahelpdesk.worldbank.org/knowledgebase/articles/378832-the-world-bank-atlas-method-detailed-methodology. [Accessed 08 December 2022].
48. Brooke HL, Atkin AJ, Corder K, Ekelund U, van Sluijs EMF. Changes in time-segment specific physical activity between ages 10 and 14 years: A longitudinal observational study. *Journal of Science and Medicine in Sport* 2016;**19**:29-34.
49. Lencucha R, Neupane S. The use, misuse and overuse of the 'low-income and middle-income countries' category. *BMJ Global Health* 2022;**7**:e009067.
50. Guthold R, Willumsen J, Bull FC. What is driving gender inequalities in physical activity among adolescents? *Journal of Sport and Health Science* 2022;**11**:424-6.
51. Katzmarzyk PT, Friedenreich C, Shiroma EJ, Lee I-M. Physical inactivity and non-communicable disease burden in low-income, middle-income and high-income countries. *British Journal of Sports Medicine* 2022;**56**:101-6.
52. You D, Hug L, Anthony D. *Generation 2030/africa.* ERIC; 2014.

53. Reilly JJ, Aubert S, Brazo-Sayavera J, Liu Y, Cagas JY, Tremblay MS. Surveillance to improve physical activity of children and adolescents. *Bulletin of the World Health Organization* 2022;**100**:815-24.
54. Ricardo LIC, Wendt A, Costa CdS, et al. Gender inequalities in physical activity among adolescents from 64 global south countries. *Journal of Sport and Health Science* 2022;**11**:509-20.
55. Freedman DA. Ecological inference and the ecological fallacy. *International Encyclopedia of the social & Behavioral sciences* 1999;**6**:1-7.
56. Howard T. Practical, professional or patriarchal? An investigation into the socio-cultural impacts of gendered school sports uniform and the role uniform plays in shaping female experiences of school sport. *Sport, Education and Society*:1-18.