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Original research

Moderate-to-vigorous intensity physical activity during school hours in a representative sample of 10–11-year-olds in Scotland☆

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ABSTRACT

Objectives: Growing concern about children and adolescent physical inactivity has made the promotion of physical activity a public health priority. International recommendations suggest children should accumulate at least 30 min of moderate-to-vigorous physical activity (MVPA) during school hours. This study assessed levels of objectively-measured MVPA in a large nationally representative sample of Scottish children aged 10–11. Risk factors for not meeting the school-hours MVPA recommendation were examined.
Design: Cross-sectional.
Methods: Mean time spent in MVPA during school hours across five weekdays was measured using Actigraph accelerometry (May 2015–May 2016). Binary logistic regression, presented as odds ratio (O.R.) and confidence intervals (C.I.), explored associations between meeting/not meeting the recommendation by sex, socioeconomic status (SES), season, and urban/rural residence in 2022.
Results: Valid data were obtained from 773 children (53.9% girls, 46.1% boys) from 471 schools. Mean daily school-hours MVPA was 29 (SD 11) minutes; 42.7% of children reached the recommendation. The odds of girls (O.R. 0.43; C.I. 0.32, 0.57) meeting the recommendation was significantly lower ($p < 0.001$) compared to boys. Children living in rural areas had higher odds (O.R. 1.49; C.I. 1.04, 2.15) of meeting the recommendation compared with those in urban areas ($p = 0.032$). No significant differences in meeting the recommendation by SES ($p = 0.700$). The overall trend for season was significant ($p < 0.001$), with lower odds of meeting the recommendation in winter compared to summer.
Conclusions: Most Scottish children aged 10–11 did not meet the 30 minute MVPA recommendation. Interventions to increase MVPA during school hours are essential to promote public health.
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Practical Implications

Schools could promote optimal MVPA for students as suggested below:

- A careful examination of the school's role in contributing to their student's daily MVPA.
- A whole-school approach to promoting health-enhancing MVPA, via a combination of PE lessons, active breaks, and recess.
- More active PE and recess, active classroom breaks, greater use of outdoor space, and use of covered playgrounds or school halls in cold and wet seasons.
- MVPA opportunities tailored to the preferences of both boys and girls are needed.

1. Introduction

Physical activity is important for children as it improves both short-term and long-term health and wellbeing.[1] Specifically, World Health Organisation (WHO) guidelines state that achieving an average of 60 min per day of moderate-to-vigorous intensity physical activity (MVPA) provides children and adolescents with a wide variety of health benefits.[2] Most children and adolescents globally have low levels of MVPA and do not meet the previous WHO recommendations (i.e., achieving at least 60 min MVPA daily).[3] Children spend a large part of their day at school, and the school setting is a significant contributor to MVPA.[4] MVPA recommendations during school hours from the American Heart Association[5] and the UK Government[6] state that children should achieve at least 30 min of MVPA during school hours.

Abbreviations: WHO:, World Health Organisation; MVPA:, Moderate to vigorous intensity physical activity; SPACES:, Studying physical activity in children's environments across Scotland; SIMD:, Scottish index of multiple deprivation; SES:, Socioeconomic status; PE:, Physical education.

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A recent systematic review[7] on physical activity (PA) levels during school hours found only three studies[8–10] that analysed the extent of achieving the school-based MVPA recommendation of 30 min using the most valid method of measuring MVPA objectively accelerometry. These studies, which included PA opportunities during different time periods at school, involved small samples[8,9] and only one sample was representative.[10] Van Stralen et al.'s[8] and Hubbard et al.'s[9] study showed that only 7%–8% of European and American elementary school students (aged 7–12) met the recommendation for 30 min of school-hours MVPA, while Grao-Cruces et al.'s study[10] indicated that in Spanish 8-year-old children, 24% of boys and 8% of girls met the recommendation. If low MVPA during school hours is widespread, then school-based strategies to further increase physical activity will need to be implemented.[11]

Development of strategies to increase school-hours MVPA will be informed by understanding risk factors for low MVPA while at school. Only two studies[8,9] have considered the risk factors associated with not meeting the 30 min daily school-hours MVPA recommendation. These two studies found very limited information, for example, it is not clear whether season and urban or rural residency are risk factors for achieving the recommendation. In summary, there is a dearth of evidence from representative samples using objective measures of MVPA, and limited evidence on risk factors for insufficient school-hours MVPA in primary schoolchildren. We, therefore, aimed, in a large nationally representative sample of Scottish children aged 10–11 years, to (a) assess the prevalence of meeting the school-hours MVPA recommendation, and (b) identify risk factors for not achieving the recommendation.

2. Methods

This present study used the data from the "Studying Physical Activity in Children's Environments across Scotland" (SPACES) study (see http://spaces.sphsu.mrc.ac.uk/home) which was carried out during school terms between May 2015–May 2016.[12] SPACES participants were recruited from the Growing up in Scotland (GUS) study, a nationally representative longitudinal cohort study originating in 2005 (https://growingupinscotland.org.uk/). Of a possible 2404 children (aged 10/11 years old) who had participated in the GUS interview conducted between September 2014 to February 2015, 2162 parents consented to be contacted by the SPACES staff. They were sent SPACES study information, registration documents, and consent forms by post. There were 1096 children who took part and both child and parent were required to sign consent forms. Data were received for this present analysis in 2022. Variables such as sex, socioeconomic status (SES), season, and urban or rural residence were obtained as part of the GUS Study, and weightings were included. These variables were also used as the potential risk factors in the present study.

An accelerometer[13,14] (ActiGraph GT3X+) was used to measure school-hours MVPA. Non-wear time periods (60 consecutive minutes of zero acceleration were recorded by the device) were removed from analyses. Accelerometry values ≥2296 per minute (cpm - count per minute) defined children's MVPA as this is commonly used to estimate MVPA, supported in the calibration study of Evenson et al. (2008).[15] We used minimum wear criteria of ≥ three days lasting ≥4 h/during school hours/day (4 h is two-thirds of a 6-hour school day or contains at least 70% of a full school daytime).[16]

School hours are not the same across Scotland, for the present study, school start and end times (range 9.00 am – 3.00 pm/8.45 am – 3.15 pm) were identified by using the primary schools' online handbooks for 2015–2016 school year found on the school's or the local authority website. School hours for each child were then identified and extracted manually from the individual accelerometry data by referring to the times from the schools' handbook. The total time spent in MVPA of children was measured, and their MVPA data were extracted for school hours only.

Other than the sex/gender, potential risk factors also included SES, season, and urban or rural setting. Students' SES was defined using the Scottish Index of Multiple Deprivation (SIMD),[17] a composite area-based measure (not based on the individual child/family) of relative social, economic, environmental, and health circumstances which are used and accepted widely in health inequality research and policy in Scotland. SIMD rank scores were grouped into 5 quintiles where 1 represented the most deprived area and 5 represented the least deprived area.[12]

Season of data collection - a four-level categorical variable (spring, summer, autumn, and winter) was used to classify the season of measurement and indicated the data collection period when each participant wore the activity monitors.[18] Regarding the urban or rural setting, children were classified according to their residency in urban or rural areas, with a standard classification method used in Scotland.[12] Population size between 3000 to ≥125,000 was classified as urban and if <3000 was classified as rural.[12]

For statistical analysis, as SPACES data were collected to be nationally representative, a weighting variable was applied ahead of the analysis. Data were weighted to compensate for potential bias to ensure the sample matched the population, and then to provide a representative sample.[12,19] - to correct the over-representation of children with higher SES in the sample. Continuous variables were presented as means and standard deviations (SD) and categorical variables are presented as numbers and percentages of the overall sample and for boys/girls separately. Binary logistic regression was used to estimate the odds (odds ratio: O.R.) of meeting the 30-minute MVPA recommendation (the dependent variable). All other variables were analysed and included in the logistic models. Models were run separately for each explanatory variable so the associations of each risk factor could be ascertained separately to check if it would be an actual risk factor for not meeting the school hours MVPA recommendation or not. P values for the overall trend and confidence intervals (C.I.) for each category of explanatory variables are presented (Table 3 in the results). Reference categories for each explanatory variable are also identified. Data were analysed with SPSS Statistics (IBM Corp, Chicago, IL; version 26). The level of significance was set at $p < 0.05$.

3. Results

Out of 1096 participants, 774 (417 girls and 357 boys aged 10 to 11 years old) provided the required accelerometry data to be included in the final SPACES study dataset.[12] For the present analysis, one participant had only 1 day of wear time data, so this participant was excluded from the data set (the total number of students was reduced to 773 from 774 included in the original SPACES study of overall MVPA). A total of 97 non-valid days (2.5% of total days measured from 89 participants) were identified and removed. So, there were 3768 valid days of accelerometry data during school days included in the present analysis (mean valid school days 4.9 per child for the 773 children).

Table 1 presents the demographic data and exploratory variable data from 773 children (mean age 11.1 years, 53.9% girl, and 46.1% boy) from 471 schools. There were 306 schools that provided one participant each; 94 schools had 2 participants and 71 schools had ≥3 participants.

The percentage (n) of children who met the 30-minute school-hours MVPA/day recommendation was 42.7% (n = 329/770 bases weighted; Table 2). Mean time spent in MVPA was 29 min (SD 11) for the overall sample; with 26 min (SD 10) accumulated for girls and 32 min (SD 11) for boys. Fig. 1 shows a more concrete picture of the distribution between girls and boys in MVPA in schools. A higher percentage of girls achieved between 10 and 30 min MVPA, while a higher percentage of boys accrued more than 30 min of MVPA during school hours.

Regarding factors associated with meeting/not meeting the 30 min MVPA per school hours recommendation, Tables 2 and 3 present the numbers and percentages of meeting the 30-min goal and the results of the logistic regression for each risk factor, respectively. The odds of girls (O.R. 0.43; C.I. 0.32, 0.57) meeting the recommendation was significantly lower ($p < 0.001$) compared to boys. Despite a higher number of children from the upper quintiles, there were no significant differences

Table 1
Participant characteristics (n(%) unweighted) split by sex and for the overall sample.

	Girls (n = 417)	Boys (n = 356)	All (n = 773)
Sex			
Girls	–		417 (53.9%)
Boys	–	–	356 (46.1%)
SES – using SIMD quintile			
1 (most deprived)	35 (8.4)	29 (8.1)	64 (8.3)
2	55 (13.2)	43 (12.1)	98 (12.7)
3	96 (23.0)	73 (20.5)	169 (21.9)
4	110 (26.4)	97 (27.2)	207 (26.8)
5 (least deprived)	121 (29)	114 (32)	235 (30.4)
Season of data collection[a]			
Winter	89 (21.3)	74 (20.8)	163 (21.1)
Spring	46 (11)	47 (13.2)	93 (12)
Summer	74 (17.7)	61 (17.1)	135 (17.5)
Autumn	207 (49.6)	175 (49.2)	382 (49.4)
Urbanicity			
Urban	313 (75.1)	254 (71.3)	567 (73.4)
Rural	104 (24.9)	102 (28.7)	206 (26.6)
MVPA minutes in school-time[b]	26 (SD 10)	32 (SD 11)	29 (SD 11)

Note: categorical variables are presented as numbers with percentages in parenthesis. The continuous variable of MVPA is presented as mean with standard deviation in parenthesis. SIMD: Scottish Index of Multiple Deprivation; SD: standard deviation.

[a] Winter is from late Dec to mid-March, Spring is from mid-March to mid-June, Summer is from mid-June to late Sept, and Autumn is from late Sept to late Dec.

[b] For MVPA the total sample (weighted) is 770 (415 girls and 355 boys).

in meeting the recommendation by SES as there were no statistically significant differences between quintiles of SIMD when C.I. were compared or the overall ($p = 0.700$) analysis by SIMD quintiles. The overall trend for seasonal influence was significant ($p < 0.001$). Those with spring (O.R. 1.54; C.I. 0.93, 2.56), and summer data collection showed higher odds (O.R. 1.98; C.I. 1.26, 3.11) and autumn data collection showed lower odds (O.R. 0.71; C.I. 0.49, 1.03) of meeting the recommendation compared to the winter reference group. There were significantly ($p = 0.032$) higher odds (O.R. 1.49, C.I. 1.04, 2.15) of children who lived in rural areas meeting the recommendation compared with those living in urban areas.

For the contribution of school hours MVPA to overall daily MVPA, we compared the 29 min of school hours' MVPA with an average of 76 min per weekday (school-hour and non-school-hour) in the previous study in the same sample,[12] and found that around 38% of students' total daily MVPA on weekdays (school days) occurred during school hours.

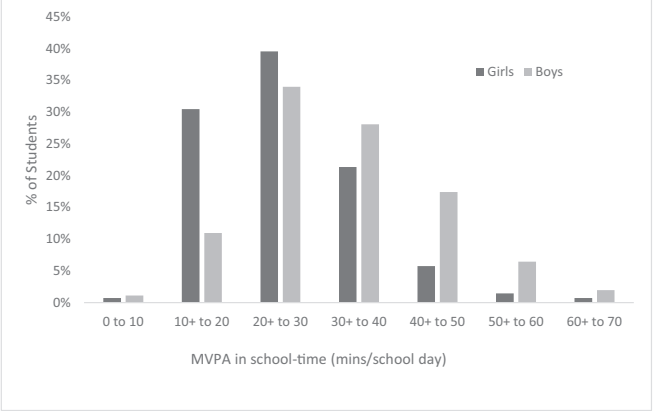

Fig. 1. The percentage of children (with boys and girls separately) accumulating MVPA in school-time per 10-minute increment.

4. Discussion

The main findings showed that only 42.7% of children accumulated ≥30 min/day of MVPA during school hours in this large sample, representative of 10- to 11-year-olds in Scotland. Gender, season, and urban/rural status were all associated with the probability of meeting the recommendation to accumulate at least 30 min MVPA per day during school hours. School hours provided an average of 29 min of MVPA per day in the present study.

While previous nationally representative studies of accelerometer measured school-hours MVPA in primary school-age children have been limited, the present study was consistent with previous findings in Europe[8,10] and the USA[9] that girls were less active and more sedentary during school hours than boys. Rooney et al.[20] found that boys (8–11-year-olds) physical education lessons and recess (break and lunch time) provided important occasions for children to be engaged in PA. Bailey et al.[21] suggested that boys' physical activity may typically be greater during PE. Some similar studies[7,22] suggested that girls are typically less active than boys due to socio-ecological factors at the individual, family, school, and environmental levels. This is possibly due to the persistence of sex/gender stereotypes.[7] Consequently, opportunities

Table 2
Weighed number (n) and percentages (% in parenthesis) meeting the school-based MVPA guidelines for each risk factor.

30 min MVPA/day during school hours	No	Yes	Total bases weighted	Total unweighted
Sex				
Girls	277 (66.7%)	138 (33.3%)	415	417
Boys	164 (46.2%)	191 (53.8%)	355	356
Total	441 (57.3%)	329 (42.7%)	770	773
SES – using SIMD quintile				
1 (most deprived)	96 (58.5%)	68 (41.5%)	164	64
2	77 (56.6%)	59 (43.4%)	136	98
3	80 (55.9%)	63 (44.1%)	143	169
4	88 (53%)	78 (47%)	166	207
5 (least deprived)	99 (61.5%)	62 (38.5%)	161	235
Total	440	330	770	773
Season				
Winter	100 (58.1%)	72 (41.9%)	172	163
Spring	45 (47.9%)	49 (52.1%)	94	93
Summer	58 (40.6%)	85 (59.4%)	143	135
Autumn	237 (65.7%)	124 (34.3%)	361	382
Total	440	330	770	773
Urbanicity				
Urban	367 (59.6%)	249 (40.4%)	616	567
Rural	74 (48.1%)	80 (51.9%)	154	206
Total	441	329	770	773

Note: total weighted number of participants used in the calculation of proportions is represented by total bases weighted. The total number of participants measured is represented by total unweighted.

Table 3
Odds ratios (OR) (95% C.I.) for meeting 30-min recommendation of MVPA during school hours.

	Meeting 30 min MVPA during school hours
Sex	
Boys	1.00 reference
Girls	0.43 (0.32, 0.57)
P value	<0.001
SES – using SIMD quintile	
5 (least deprived)	1.00
4	1.40 (0.89, 2.15)
3	1.24 (0.78, 1.97)
2	1.25 (0.79, 2.00)
1 (most deprived)	1.25 (0.79, 1.96)
P value	0.700
Season of data collection	
Winter	1.00
Spring	1.54 (0.93, 2.56)
Summer	1.98 (1.26, 3.11)
Autumn	0.71 (0.49, 1.03)
P value	<0.001
Urbanicity	
Urban	1.00
Rural	1.49 (1.04, 2.15)
P value	0.032

Note: all models control for school number; bolded category is significant at p = 0.003.

for physical activities offered by schools and communities may typically be more attractive to boys than girls.[22]

We found that SES was not a significant predictor of meeting the school-hours MVPA recommendation, consistent with Hubbard et al.'s study.[9] In Scotland, the school environment and physical activity provision should vary little by SES. Almost all Scottish children and adolescents attend the public school system, and schools follow the same national curriculum[23] with similar levels of funding (in fact additional funding per student for schools in lower SES areas). Consequently, schools may have similar opportunities and capacity to engage all children in MVPA broadly equally during school hours.

The reasons for rural settings being associated with higher school-hours MVPA than urban schools are unclear, but rural schools may have more space for outdoor physical activity than urban schools.[18] The seasonal difference in school-hours MVPA in the present study may be explained by the fact that in Scotland primary schools tend to keep children inside during recess and lunchtimes when it is windy or rains heavily which happens less often during summer. Ridgers et al.[24] and Harrison et al.[25] found that temperature[24] and rainfall[25] are negatively associated with PA.

The present study provides support for the concept that schools need to develop a whole-school approach to promoting health-enhancing MVPA, via a combination of PE lessons, recess,[20] more active classroom breaks,[26] and greater use of outdoor space[27] with covered playgrounds in cold and wet seasons. As suggested by Harrison et al.[25] a focus on encouraging indoor physical activities in wet weather may help children remain active during school hours.[25] While Zahi-Thanem et al.[28] indicated that increased outdoor time increases MVPA and Telford et al.[22] recommended that opportunities for MVPA should be tailored to the preferences of boys and girls.

The MVPA accrued during school hours in the present study, while lower than recommendations, was higher than from other European countries.[8,10] The differences may be partially explained by using different accelerometry cut points to classify physical activity intensities, as well as due to the differences in the educational system and weather conditions. The 2296 count per minute Actigraph cut-off used to define MVPA provides a conservative threshold for estimating time spent in MVPA - if the appropriate cut-point to classify MVPA in children is higher than this, then the prevalence of meeting the 30-minute recommendation will be even lower than observed in the present study.[29]

The present study had some strengths. First, the dataset used was from a large representative sample of children across Scotland - few other international studies of school hours MVPA have been based on large nationally representative samples.[7] Second, MVPA was measured objectively by using accelerometers - accelerometry is a valid method for measuring actual levels (intensity) of physical activity.[13] Third, few previous studies addressed factors influencing MVPA accumulated during school hours.[7]

There were also a few limitations in this study. A total of ninety-seven non-valid days across the entire study were identified because eighty-nine participants provided invalid accelerometer data on some days. However, compared with a total of 3768 valid days of data, the percentage (2.5% of non-valid days) was small and should not make much difference to the estimates of time spent in MVPA in the sample. Second, we were limited to a small number of individual and family-based potential risk factors for not meeting the school-hours MVPA recommendation (sex, SES, season, and urban or rural residence) available in the original SPACES dataset.[12] Other potential risk factors for insufficient MVPA (such as the number and arrangement of break times, and the amount of MVPA provided during school PE lessons) were not collected in SPACES study. Third, the participants were restricted to children aged 10–11, the findings may not be generalisable to younger children or older youths. Fourth, the present study examined school-hours MVPA and not where that came from, for example, recess, PE lessons, or class time.

5. Conclusions

This present study demonstrated that a relatively high proportion (around 57%) of children (regardless of sex, SES, season, or urban/rural setting) did not meet the 30-minute MVPA recommendation during school hours. School is a valuable setting to prevent chronic disease as it creates a unique opportunity to reach children across the population, and during a critical period in establishing health behaviours.[30] A careful examination of the school's role in contributing to their student's daily MVPA is essential. Further studies on how to promote physical activity within school hours and settings with a whole school approach are recommended.

CRediT authorship contribution statement

Lan S Wong: Data management and analysis; Data interpretation; Conceptualization; Writing – original draft; Writing – review & editing. John J. Reilly: Provided scholastic views; Data interpretation; Writing – review & editing. Paul McCrorie: Data management and analysis; Writing – review & editing. Deirdre M. Harrington: Data analysis & interpretation; Writing – review & editing. All authors provided important intellectual content and approved the final version of the manuscript.

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Confirmation of Ethical Compliance

Ethical approval was provided by the College of Social Sciences, University of Glasgow, and all participants and/or their legal guardians consented to be contacted and sent data back to SPHSU for processing to complete the SPACES study. Prior to sharing data, agreements were

established between the authors of the present study and the MRC/CSO Social and Public Health Sciences Unit, University of Glasgow, Scotland.

Declaration of Interest Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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