Health-related Measures of 6- and 10-year-old Irish Primary School Children by Sex and School Socio-economic Status

Mai O' Leary, MSc
Tara Coppinger, PhD
Cian O' Neill, PhD
Seán Lacey, PhD
Elaine Rush, PhD
Con Burns, PhD

Objective: This paper provides an assessment of the health status of Irish children, across sex and school socio-economic status (SES). *Methods*: Children (N = 655) from 10 schools participated in the evaluation, whereby body composition, blood pressure, cardiorespiratory fitness and physical activity measures were recorded. Results: Children from low SES schools had larger waists and slower run times ($p < .05$) than children from middle/high SES schools. Six-year-old children from low SES schools had higher body mass index (BMI) scores and resting heart rates; they also were more likely to be overweight or obese ($p < .01$) compared to their middle/high SES counterparts. Conclusions: Policy efforts to improve the health of Irish children should prioritize low SES schools.

***Key words*: child health status; body composition; blood pressure; child fitness; physical activity; body mass index (BMI)**
***Health Behav Policy Rev.*™ 2018;5(3):67-76**
DOI: https://doi.org/10.14485/HBPR.5.3.7

Childhood obesity is one of the most serious public health challenges of the 21st century[1] and if current trends continue, the global prevalence will reach 60 million by 2020.[2] Among the 35 Organisation for Economic Co-operation and Development countries, the United States leads with over 30% of children aged 5 to 17 years overweight or obese but Ireland is also ranked in the top 50%, with more than 20% of children overweight or obese, including a higher prevalence for girls than boys.[3] Obese youth are more likely to present with risk factors for cardiovascular disease (CVD) and to remain obese into adulthood.[1] Therefore, early identification of the health status of children is crucial so that appropriate interventions can be implemented.

Only 19% of Irish primary school children undertake daily physical activity (PA), and one in 4 children are unfit and have elevated blood pressure (BP).[4] Boys are more active and are more likely to engage in extracurricular sport than girls[4] and inequalities exist across social class groups for physical inactivity, type of PA, and body mass index (BMI). Children from lower socio-economic status (SES) groups are more likely to spend time on sedentary activities compared to children from higher SES groups and participation in structured sports clubs has been found to increase with family income.[5] Body size also has been related to social class, with 33% of 9-year-old children of adults from semi-skilled/unskilled backgrounds classified as overweight or obese, compared to 22% of children whose parents work in professional/managerial roles.[5] However, few Irish studies have examined

Mai O'Leary, PhD Candidate, Tara Coppinger, Lecturer, Cian O' Neill, Head of Department, Con Burns, Senior Lecturer, Department of Sport, Leisure and Childhood Studies, Cork Institute of Technology, Bishopstown, Cork, Republic of Ireland. Seán Lacey, Lecturer, Department of Mathematics, Cork Institute of Technology, Bishopstown, Cork, Republic of Ireland. Elaine Rush, Professor, Child Health Research Centre, Faculty of Health and Environmental Sciences, Auckland University of Technology, Auckland, New Zealand.
Correspondence Mai O' Leary; mai.oleary@cit.ie

SES and objective markers of health (anthropometry, blood pressure, fitness and PA) of children, particularly younger age groups (5-6-year-olds).

The purpose of this study is to: (1) assess selected measures of health among Irish 6- and 10-year-old primary school children; and (2) compare these measures across sex and school SES. Such data will help to inform the status and effectiveness of existing policies and practices intended to improve the health of Irish children; moreover, they could potentially support the design of new policies to those most at need. The findings also will provide baseline measures to inform an Irish school-based health promotion intervention entitled: 'Project Spraoi' (http://projectspraoi.cit.ie).

METHODS

Sampling Framework

Information about the Project Spraoi initiative, including design, protocol, and sampling has been published elsewhere.[6] It is derived from a New Zealand (NZ) school-based health promotion intervention entitled 'Project Energize,' (www.projectenergize.org.nz) which has shown measurable improvements in the health of NZ children.[7] Briefly, descriptive data relating to all mainstream primary schools in Cork City and County Cork were obtained from the Department of Education and Skills website (www.education.ie/en/) in 2013. Schools were stratified by sex (male, female, or mixed), low SES versus middle/high SES,[8] area of residence (urban or rural), school size (number of pupils), and proximity (<20km) to the research institute (Cork Institute of Technology, Ireland). Within Ireland, Cork is the largest and most southerly of the 32 counties, accounting for 11% of the population. Children in Cork are found to have similar health characteristics to those from the rest of Ireland.[9]

Principals of stratified schools were contacted and a full outline of the study's aim, proposed procedures and the requirement for evaluation measures were discussed. Ten schools that expressed a willingness to participate that were not currently participating in another PA and/or healthy eating/nutrition intervention were recruited, using a convenience sampling approach. Although the study is limited in that schools were selected via convenience sampling, all mainstream school types in Cork and Ireland (urban, rural, single-sex girls, single-sex boys, mixed, low SES and middle/high SES) were represented. Three of the participating schools (30%) were classified as being from areas of low SES; having schools above the national figure of 21% allows for reduced class size in low SES schools.[10] Low SES schools in Ireland are referred to as DEIS (delivering equality of opportunity in schools) under the Department of Education and Skills school support program and are classified based on a combination of parent employment status, local authority accommodation (social housing for people who cannot afford to buy their own homes), lone parenthood, travelers (community within Ireland who are traditionally nomadic), free book grants (funding provided to schools for assistance with books) and large families.[8]

Participants

A total of 655 children (6-year-olds, N = 332; 10-year-olds, N = 323) from 10 Cork schools participated (52.8% boys; 47.2% girls). These age groups were chosen on the basis that: (1) they mark sensitive periods of growth for the child (mid-childhood & early adolescence);[11] and (2) they allow for international comparison with children evaluated through Project Energize.[7] Of the 655 children, 26.7% attended schools classified as low SES under the Department of Education and Skills school support program.[8]

Testing Protocol and Measures

Most Project Energize evaluation methods (anthropometric and physiological) were replicated.[12] In addition, objective accelerometer-measures of PA and sedentary behavior (SB) in a subset of participants (N = 442) were collected. All measures were conducted by a team of 5 researchers that were trained in health-related data collection techniques.

International Obesity Task Force age and sex-specific BMI criteria were used to categorize children as thin, normal weight, overweight, or obese[13] and waist circumference percentiles[14] were used to estimate overweight and obesity, using the 85th and 95th percentiles, respectively. Time taken to complete a 550m run was performed on an outdoor surface (grass, artificial turf, weather-synthetic track), after the completion of the anthropometric and physiological test battery.

Table 1
Mean and Standard Deviation (SD) of Continuous Variable and Percentage of Categorical Variables by Age Cohort and Sex

	6-year-old children				10-year-old children			
	Boys		Girls		Boys		Girls	
	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD
Age (years)	163	6.1 ± 0.4	169	6.1 ± 0.5	183	10.0 ± 0.4	140	9.9 ± 0.4
BMI[a] (kg/m)	163	16.33 ± 1.60	167	16.48 ± 2.03	179	17.82 ± 2.75	140	18.15 ± 2.92
WC[b] (cm)	162	54.7 ± 4.2	167	54.3 ± 5.1	180	62.5 ± 7.4	140	61.4 ± 8.1
Systolic BP[c] (mmHg)	148	101.1 ± 10.2	155	102.3 ± 9.5	165	109.3 ± 12.5	134	110.5 ± 11.7
Diastolic BP[c] (mmHg)	148	58.7 ± 9.0	154	61.3 ± 9.6	165	64.3 ± 9.7	134	66.8 ± 9.5
Resting HR[d] (bpm)	148	87.9 ± 11.3	154	89.7 ± 11.9	165	80.1 ± 10.8	134	84.9 ± 13.5
Run Time (secs)	153	211.0 ± 26.8	154	228.4 ± 33.5	168	169.9 ± 31.2	129	184.7 ± 32.7
MVPA[e] (mins)	62	64.7 ± 14.4	67	57.7 ± 16.4	86	64.3 ± 20.0	61	48.6 ± 16.7
Sedentary (hrs)	62	7.5 ± 0.9	67	7.7 ± 0.9	86	8.7 ± 1.0	61	9.1 ± 0.7
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
% Overweight & Obese (BMI)[a]	26	16.0	33	19.8	32	17.9	34	24.3
% Overweight & Obese (WC)[b]	30	18.5	33	19.8	41	22.8	39	27.8
% Achieving 60 mins MVPA[e]	37	59.7	30	44.8	46	53.5	12	19.7

Note.
a: BMI – Body mass index
b: WC – Waist circumference
c: BP – Blood pressure
d: HR – Heart rate
e: MVPA – Moderate to vigorous physical activity

PA and SB were objectively measured over 7 days using Actigraph triaxial accelerometers (MTI model 7164, Fort Walton Beach, FL) at 30Hz/5 second epochs, on a subsample of 442 children. The minimum wear time criteria was a 600-minute/day threshold, on 3 or more separate days,[15] which has been shown to give adequate reliability and power.[16,17] Non-wear time was defined as 20 consecutive minutes of zero counts.[18] Minutes of PA of different intensities was calculated using cut points developed by Evenson et al[19] with children of similar ages. Outcome variables calculated for the current study were mean daily minutes in sedentary, low, moderate and vigorous PA. Adherence to the recommended PA guidelines was based on the proportion of children achieving 60 minutes of MVPA per day.[20]

Data Analysis

All data were analyzed using IBM SPSS (Statistical Package for Social Studies), Version 22. Data were explored for normality using descriptive statistics, histograms, and Kolmogorov-Smirnov or Shapiro-Wilk normality tests. Means and standard deviations (SD) were calculated for all continuous variables and frequencies were used to summarize categorical variables. Twelve participants were ex-

Table 2
Mean, Standard Deviation (SD), 95% Confidence Interval (CI) and Univariate Analysis for Health Measure among Boys and Girls

	6-year-old children					10-year-old children				
	Boys		Girls			Boys		Girls		
	N	Mean ± SD [95% CI]	N	Mean ± SD [95% CI]	p-value	N	Mean ± SD [95% CI]	N	Mean ± SD [95% CI]	p-value
BMI[a] (kg/m²)	163	16.33 ± 1.60 [16.08, 16.58]	167	16.48 ± 2.03 [16.17, 16.79]	.375	179	17.82 ± 2.75 [17.41, 18.23]	140	18.15 ± 2.92 [17.66, 18.64]	.210
WC[b] (cm)	162	54.7 ± 4.2 [54.1, 55.4]	167	54.3 ± 5.1 [53.5, 55.1]	.652	180	62.45± 7.4 [61.4, 63.6]	140	61.4 ± 8.1 [60.0, 62.7]	.662
Systolic BP[c] (mmHg)	148	101.1 ± 10.2 [99.4,102.7]	154	102.3 ± 9.5 [100.8, 103.8]	*.753	165	109.3 ± 12.5 [107.4, 111.2]	134	110.5 ± 11.7 [108.5, 112.5]	.750
Diastolic BP[c] (mmHg)	148	58.7 ± 9.0 [57.3, 60.2]	154	61.3 ± 9.6 [59.8, 62.8]	.204	165	64.3 ± 9.7 [62.8, 65.8]	134	66.8 ± 9.5 [65.2, 68.5]	.228
Resting HR[d] (bpm)	148	87.9 ± 11.3 [86.1, 89.7]	154	89.7 ± 11.9 [87.8, 91.6]	.106	165	80.1 ± 10.8 [78.4, 81.8]	134	84.9 ± 13.5 [82.6, 87.2]	.003
Run Time (secs)	153	211.2 ± 26.8 [206.9, 215.5]	154	228.4 ± 33.5 [223.1, 233.8]	* < .0005	168	169.9 ± 31.2 [165.1, 174.6]	129	184.7 ± 32.7 [179.0, 190.4]	< .0005
MVPA[e] (mins)	62	64.7 ± 14.4 [61.1, 68.4]	67	57.7 ± 16.4 [53.7, 61.7]	*.001	86	64.3 ± 20.0 [60.0, 68.6]	61	48.6 ± 16.7 [44.3, 52.9]	< .0005
Sedentary Time (hrs)	62	7.5 ± .9 [7.2, 7.7]	67	7.7 ± .9 [7.5, 7.9]	.073	86	8.7 ± 1.0 [8.5, 9.0]	61	9.1 ± .7 [8.9, 9.2]	.028

Note.
a: BMI – Body mass index
b: WC – Waist circumference
c: BP – Blood pressure
d: HR – Heart rate
e: MVPA – Moderate to vigorous physical activity

cluded from the BP measurements due to values falling outside the testing protocol on 2 or more occasions and 2 participants were excluded from the cardiorespiratory fitness test measurement due to physical disability. Missing values for all other measurements were due to children being absent on the day of testing. Levene's test was used as criteria for satisfying the assumption of homogeneity of variance.

A 2-way between-group analysis of variance (ANOVA) explored differences across sex and school classification and was followed up with Bonferroni-corrected *post hoc* tests to explore subgroup differences. Data are presented as mean ± SD and 95% confidence intervals. A chi-square test compared categorical variables across sex and school classification. All statistical testing was performed at a .05 level of significance and effect size was reported using partial eta squared.

RESULTS

Overview of Health Status

Anthropometric, physiological, and behavioral measures are summarized by age cohort and sex in Table 1. Overall, 129 (58.1%) 6-year-olds and 147 (66.8%) 10-year-olds achieved the minimum accelerometer wear time criteria, respectively. Among 6-year-olds, girls recorded 57.7 ± 16.4 minutes of MVPA per day, and boys recorded 64.7 ± 14.4 mean minutes of MVPA per day. The 10-year-old boys recorded 64.3 ± 20.0 minutes of MVPA per day and 10-year-old girls recorded 48.6 ± 16.7 minutes of MVPA per day.

Categories of selected health-related measures are presented in Table 1. A total of 16.0% of 6-year-old boys and 19.8% of 6-year-old girls were overweight and obese. Among 10-year-old children, 17.9% of boys and 24.3% of girls were overweight and obese. Based on waist circumference centiles,[14] the

Table 3
Mean, Standard Deviation (SD), 95% Confidence Interval (CI) and Univariate Analysis for Health Measure among Children in Low SES (Socio-economic Status) and Mid/High SES Schools

	6-year-old children					10-year-old children				
	Low SES		Mid/High SES			Low SES		Mid/High SES		
	N	Mean ± SD [95% CI]	N	Mean ± SD [95% CI]	p-value	N	Mean ± SD [95% CI]	N	Mean ± SD [95% CI]	p-value
BMI[a] (kg/m²)	89	17.04 ± 2.41 [16.53, 17.55]	241	16.18 ± 1.50 [15.98, 16.37]	< .0005	86	18.34 ± 3.28 [17.64,19.04]	233	17.82 ± 2.64 [17.48, 18.17]	.104
WC[b] (cm)	89	56.3 ± 6.0 [55.0, 57.6]	240	53.8 ± 3.9 [53.3, 54.3]	< .0005	86	65.1 ± 9.5 [63.1, 67.2]	234	60.9 ± 6.6 [60.0, 61.7]	< .0005
Systolic BP[c] (mmHg)	70	100.4 ± 9.9 [98.0, 102.8]	232	102.1 ± 9.8 [100.8, 103.4]	*.281	73	111.6 ± 10.7 [109.0, 114.0]	226	109.3 ± 12.5 [107.6, 110.9]	.207
Diastolic BP[c] (mmHg)	70	58.4 ± 9.0 [56.3, 60.6]	232	60.5 ± 9.5 [59.3, 61.7]	.099	73	63.8 ± 8.4 [61.8, 65.7]	226	66.0 ± 10.0 [64.7, 67.3]	.078
Resting HR[d] (bpm)	70	92.3 ± 11.6 [89.6, 95.1]	232	87.7 ± 11.5 [86.3, 89.2]	.008	73	83.1 ± 12.2 [80.3, 86.0]	226	82.0 ± 12.3 [80.4, 83.6]	.358
Run Time (secs)	82	229.2 ± 38.4 [220.8, 237.7]	225	216.4 ± 27.9 [212.8, 220.1]	*.004	80	191.5 ± 30.3 [184.8, 198.3]	217	170.7 ± 31.7 [166.5, 175.0]	< .0005
MVPA[e] (mins)	36	62.2 ± 18.7 [55.9, 68.6]	93	60.6 ± 14.6 [57.6, 63.6]	*.399	56	66.0 ± 23.1 [60.0, 72.2]	91	52.7 ± 16.4 [49.3, 56.1]	< .0005
Sedentary Time (hrs)	36	7.8 ± 1.0 [7.4, 8.1]	93	7.5 ± .9 [7.4, 7.7]	.258	56	8.8 ± 1.0 [8.5, 9.1]	91	8.9 ± .8 [8.8, 9.1]	.543

Note.
a: BMI – Body mass index
b: WC – Waist circumference
c: BP – Blood pressure
d: HR – Heart rate
e: MVPA – Moderate to vigorous physical activity

prevalence of overweight and obesity was 19.1% for the 6-year-olds and 25.1% for the 10-year-olds. A total of 59.7% of 6-year-old boys versus 44.8% of 6-year-old girls and 53.5% of 10 year-old-boys versus 19.7% of girls met daily MVPA recommendations.

Comparison of the Health-related Measures among Boys and Girls

Across both age categories, boys completed the 550m run in a faster time, had higher mean minutes of daily MVPA, and lower mean hours of daily sedentary time, in comparison to girls ($p < .05$), (Table 2). Ten-year-old boys were found to have lower resting heart rates than their female counterparts ($p = .003$); although this trend was not evident in the 6-year-old group ($p = .106$).

Comparison of the Health-related Measures among Children in Low SES Schools versus Middle/High SES Schools

Children from low SES schools had higher waist circumferences and slower run times compared to children from middle/high SES schools, and this trend was evident in both the 6- and 10-year-old groups ($p < .05$). Among 6-year-old children, body mass, BMI and resting heart rate were higher in the low SES cohort ($p < .05$). Among 10-year-old children, MVPA was significantly higher among low SES children compared to middle/high SES children ($p < .05$) (Table 3).

Post hoc Comparisons

Where statistically significant differences were found (Tables 2 and 3), follow-up *post hoc* tests (Ta-

Table 4
Mean Difference and Simple Main Effect for Systolic BP[a], Run Times, and MVPA[b] by Sex and School Socio-economic Status (SES) Classification using the Bonferroni Correction Method

	6-year-old children						
	N	Factor	Mean Difference		p-value	η_p^2	95% CI[c] for Difference
Systolic BP[a] (mmHg)	148	Boys	1.7	Low SES – Mid/High SES	.392	.002	[-2.22, 5.64]
	154	Girls	4.6	Mid/High SES – Low SES	.011	.022	[1.08, 8.15]
	70	Low SES	3.6	Boys – Girls	.129	.008	[-1.06, 8.23]
	232	Mid/High SES	2.7	Girls - Boys	.033	.015	[0.22, 5.27]
Run Time (secs)	153	Boys	2.2	Low SES – Mid/High SES	.699	< .0005	[-8.88, 13.2]
	154	Girls	20.1	Low SES – Mid/High SES	< .0005	.046	[9.77, 30.50]
	82	Low SES	29.8	Girls - Boys	< .0005	.063	[16.84, 42.82]
	225	Mid/High SES	11.9	Girls - Boys	.003	.029	[4.06, 19.68]
MVPA[b] (mins)	62	Boys	9.3	Low SES – Mid/High SES	.038	.034	[0.51, 18.04]
	67	Girls	4.2	Mid/High SES – Low SES	.306	.008	[-3.88, 12.24]
	36	Low SES	16.8	Boys – Girls	.001	.080	[6.71, 26.96]
	93	Mid/High SES	3.4	Boys - Girls	.288	.009	[-2.89, 9.64]

Note.
a: BP – Blood pressure
b: MVPA – Moderate to vigorous physical activity
c: CI – Confidence interval

ble 4) revealed that girls from low SES schools had significantly lower systolic BP than girls from middle/high SES schools ($p = .011$). In middle/high SES schools, boys had significantly lower systolic BP than girls ($p = .033$). Boys completed the run in a faster time in comparison to girls, regardless of school type. Girls attending middle/high SES schools were significantly faster than girls attending low SES schools ($p < .0005$) and boys from low SES schools had significantly higher MVPA (16.8 minutes; $p = .001$) than girls from low SES schools. Additionally, low SES boys had significantly higher MVPA (9.3 minutes; $p = .038$) than middle/high SES boys.

BMI Categories by Sex and School Classification

Six-year-olds attending low SES schools were more likely to be overweight and obese compared to their middle/high SES counterparts (28.1% vs 14.1%; $p = .005$). No statistically significant difference in levels of overweight and obesity was found among 6- and 10-year-old participants across sex or among 10-year-olds across school classification (Table 5).

PA Guidelines by Sex and School Classification

Ten-year-old girls were least likely to achieve the recommended 60 minutes of daily MVPA, with only 19.7 % reaching the threshold in comparison to 53.5% of 10-year-old boys ($p < .0005$). A higher percentage of 10-year-old children in low SES schools (55.4%) versus middle/high SES schools (29.7%) achieved these recommendations ($p = .003$) but this finding was not present among 6-year-olds, across sex or school classification (Table 5).

DISCUSSION

This study is the first of its kind to examine an extensive range of health-related measures of Irish children across sex and school SES. About one in 5 participants were either overweight (13.7%) or obese (5.5%), consistent with previous representative samples of Irish primary schoolchildren[21] and shows Irish children to have among the highest rates of overweight and obesity in Europe.[22] Referencing waist circumference percentiles,[14] however, the prevalence of obesity was higher at 11.6%. This finding is a cause for concern, because evidence

Table 5
Percentage of Categorical Variables by Age Cohort, Sex and School Socio-economic Status (SES)

	6-year-olds					10-year-olds				
	Boys		Girls			Boys		Girls		
	N	%	N	%	p-value[a]	N	%	N	%	p-value[a]
% Overweight & Obese (BMI)[b]	26	16.0	33	19.8	.448	32	17.9	34	24.3	.207
% Achieving 60 mins MVPA[c]	37	59.7	30	44.8	.129	46	53.5	12	19.7	< .0005
	Low SES		Mid/High SES			Low SES		Mid/High SES		
	N	%	N	%	p-value[a]	N	%	N	%	p-value[a]
% Overweight & Obese (BMI)[b]	25	28.1	34	14.1	.005	22	25.6	44	18.9	.248
% Achieving 60 mins MVPA[c]	21	58.3	46	49.5	.479	31	55.4	27	29.7	.003

Note.
a: p-value for difference in health categories using the Chi-squared test
b: BMI – Body mass index
c: MVPA – Moderate to vigorous physical activity

suggests waist circumference is a more relevant health outcome measure than BMI.[23]

The finding that 10-year-old boys were more active and had higher fitness scores than girls concurs with studies among European[24,25] and American[26,27] children. The marked age related decline in PA levels found among our participants also supports previous research.[24,28] Yet, when comparing the number of children who met daily PA guidelines (45.3%) to previous Irish findings (19% of primary school children and 25% of 9-year-olds), much higher levels of adherence are evident. These studies are poor comparisons, however, because they were carried out among different age groups to those of the present study and only self-report methods were used.[4,5] For clear comparisons to be made, more objective data need to be collected among primary schoolchildren.

Both BMI and waist circumference data found in the current study are similar to those reported in Ireland's Childhood Obesity Surveillance Initiative (COSI).[21] Our study revealed that children spend 8 hours per day engaged in SB which supports results from a systematic review that concluded that children spend up to 9 hours per day sedentary.[29] Although combined assessment of children's anthropometric, physiological, and behavioral variables, and SES is sparse both in Ireland and internationally, there is some evidence to suggest that socio-economic inequalities in cardiovascular risk factors exist in childhood.[30-32] Children attending low SES schools in NZ have been found to have increased BMI,[30] as were those who had lower family incomes in both the United States[31] and Europe.[32]

We found that across both cohorts, boys and girls attending low SES schools were almost 3 times as likely to be obese in comparison to their middle/high SES counterparts. Whereas this finding was not statistically significant, the magnitude is concerning and supported by both a representative study[33] and a systematic review[34] that show a strong relationship between obesity among children and disadvantaged households. Such findings suggest that policymakers should consider prioritizing the implementation of interventions that target overweight and obesity to children attending low SES schools.

There was a statistically significant simple main effect for 6-year-old children between sex and school classification for systolic BP, cardiorespiratory fitness, and MVPA. Girls from middle/high SES schools had higher systolic BP than those from low SES schools and boys from middle/high SES schools. The high BP in the middle/high SES girls is not readily explained by sex or SES and differs from previous research that found sex differences to originate only during adolescence.[35] In a review article, Colhoun et al concluded that low SES status is associated with higher BP in adults, most consistently in women, but found in most cases, a lack of association in studies conducted with children.[36] When reviewing the findings by school location, however, Rush et al found no statistically significant difference in systolic and diastolic BP across SES, but did find higher values in rural compared to urban children,[30] which was also found in the current study and in research undertaken by Grotto et al.[37] Potential reasons for this difference between urban and rural children should be explored in future research.

The difference in systolic BP we found could partly be influenced by the higher levels of MVPA among low SES girls and potential lowering effect this may have on BP levels. Leary et al reported such a finding when they found an association between higher levels of PA and lower levels of BP among 11-12-year-old children from the United Kingdom.[38] Encouraging children to increase their MVPA also may help to reduce their systolic BP and could potentially benefit long-term cardiovascular health.

Interestingly, 10-year-old participants and 6-year-old boys attending low SES schools had significantly higher MVPA than their middle/high SES counterparts. Previous studies from other countries report mixed results concerning the relationship between SES and objectively measured PA.[39,40] Scottish 6-year-olds[39] from both affluent and deprived groups were found not to differ in time spent being physically active, whereas low SES Swedish 6-year-olds[40] had higher PA levels than higher SES groups. A reason behind this difference could be due to low SES children having greater freedom to play,[41] which in turn could contribute to higher MVPA. Further research in this area is warranted, which also considers mode of transport to school, given the finding elsewhere that as household income increases, the likelihood of active commuting to school decreases,[42] thereby reducing what could be an ideal opportunity of increasing daily MVPA.

Girls from low SES schools took longer to complete the 550m run than girls from middle/high SES schools and all boys completed the run in a faster time to that of girls. Few studies have examined, in-depth, the influence of SES on physical fitness, and the findings are, so far, contradictory.[43,44] The discrepancies among studies could be due to the different methods used to assess fitness alongside SES factors. Jin et al found that 2-9-year-olds with lower family income were less physically fit than those with higher family income but this study assessed physical fitness using the Fitnessgram protocol.[31] A possible reason for differences in fitness could be that children who attend middle/high SES schools are more accustomed to structured sport[5] which requires more adherence to structured fitness programs or testing. Such activities may be cost-prohibitive for the parents of children attending low SES schools,[45] which may reflect the finding which shows participation in after school sport in Ireland to be lower among children from lower social classes.[4] Although our aim was not designed to ascertain such differences, it does confirm the need for translational research into equitable and cost-effective approaches that target the fitness levels of girls attending low SES schools in Ireland.

A strength of our study is the extensive range of objective health measures undertaken among children across sex and school classification, which have not been reported in Ireland. It is important to recognize, however, that the identification of designated disadvantaged schools in Ireland is a measure of deprivation for the school's geographical area.[8] Providing a measure of SES for each individual participant may be more accurate and should be considered in the design of future studies.

Conclusion

We provide evidence to show health inequalities present in Irish children as young as 6 years of age. One in 5 Cork primary schoolchildren are overweight or obese and a substantial part of their waking day is being spent sedentary. Furthermore, less than half of participants reached the daily national PA guidelines, with girls being identified as particularly at risk. Further research is warranted to understand why children attending low SES schools record higher levels of MVPA but still, have higher BMI, waist circumference and lower fitness scores than children attending middle/high SES schools.

IMPLICATIONS FOR HEALTH BEHAVIOR OR POLICY

Our evidence provides a clear case for action in addressing the health inequalities evident in Irish primary school-aged children. Policymakers need to consider targeting interventions for those as young as 6 years of age that are aimed at improving PA and fitness and preventing overweight and obesity. They should also prioritize the distribution of resources to girls and children attending low SES schools. At the school level, developing policies that place greater emphasis and opportunity for increasing MVPA and cardiorespiratory fitness across the school day, particularly for girls, should be re-examined. As school resources may be limited, we encourage school principals to engage and seek assistance from national health and education departments along with institutions of higher learning who have a shared vision to reduce health inequalities and improve the overall health of children. Such partnerships have the potential to bring intervention, evaluation, and resources to schools.

Our results can be summarized in 2 policy recommendations:

- Whole school interventions need to be designed and evaluated that target the prevention of overweight and obesity through the promotion of cardiorespiratory fitness and MVPA among primary school aged children that pay special attention to girls and children attending low SES schools.
- Schools, should develop policies that provide children with increased opportunity for MVPA and fitness across the school day and seek support from multi-stakeholders to implement strategies that successfully engage girls and address school SES differences.

Human Subject Approval Statement

Ethical approval was attained from the Cork Institute of Technology's Research Ethics Committee in September 2013.

Conflict of Interest Disclosure Statement

All authors of this article declare that they have no conflicts of interest.

References

1. World Health Organization. Global Strategy on Diet, Physical Activity and Health. Available at: www.who.int/dietphysicalactivity/childhood_consequences/en/. Accessed November 16, 2015.
2. De Onis M, Blössner M, Borghi E. Global prevalence and trends of overweight and obesity among preschool children. *Am J Clin Nutr*. 2010;92(5):1257-1264.
3. Organisation for Economic Co-operation and Development. Obesity Update 2014. Available at: http://www.oecd.org/health/obesity-update.htm. Accessed July 16, 2017.
4. Woods C, Tannehill D, Quinlan A, et al. *The Children's Sport Participation and Physical Activity Study (CSPPA)*. Dublin, Ireland: School of Health and Human Performance, Dublin City University and The Irish Sports Council; 2010.
5. Williams J, Greene S, Doyle E, et al. *Growing Up in Ireland. National Longitudinal Study of Children. The Lives of 9-year-olds*. Dublin, Ireland; 2009. Available at: file:///C:/Users/Robert%20J.%20McDermott/AppData/Local/Packages/Microsoft.MicrosoftEdge_8wekyb3d8bbwe/TempState/Downloads/Growing%20Up%20in%20Ireland%20-%20The%20lives%20of%20nine-year%20olds.pdf. Accessed December 20, 2017.
6. Coppinger T, Lacey S, O'Neill C, Burns C. 'Project Spraoi': a randomized control trial to improve nutrition and physical activity in school children. *Contemp Clin Trials Commun*. 2016;3:94-101.
7. Project Energize, Sport Waikato, Auckland University of Technology. An evaluation of nutrition and physical activity in Waikato primary schools. Project Energize June 2008 to June 2011. Available at: www.sportwaikato.org.nz/programmes/team-energize/is-it-working.aspx. Accessed December 14, 2015.
8. Archer P, Sofrioniou N. The assessment of levels of disadvantage in primary schools for DEIS. Dublin, Ireland: Education Research Centre; 2008.
9. Central Statistics Office. Population by sex, province county or city, general health, age group and census year. Available at: www.cso.ie/px/pxeirestat/Statire/SelectVarVal/Define.asp?Maintable=CD880&Planguage=0. Accessed August 4, 2017.
10. Kavanagh L, Weirand S, Moran E. *The Evaluation of DEIS: Monitoring Achievement and Attitudes among Urban Primary School Pupils from 2007 to 2016*. Dublin, Ireland: Educational Research Centre; 2017. Available at: https://www.education.ie/en/Schools-Colleges/Services/DEIS-Delivering-Equality-of-Opportunity-in-Schools-/DEIS-Supporting-Information/DEIS-ERC-Report-2017.pdf. Accessed December 20, 2017.
11. Cameron N, Demerath EW. Critical periods in human growth and their relationship to diseases of aging. *Am J Phys Anthropol*. 2002;(Suppl 35):159-184.
12. Graham D, Appleton S, Rush E, et al. Increasing activity and improving nutrition through a schools-based programme: Project Energize. 1. design, programme, randomisation and evaluation methodology. *Public Health Nutr*. 2008;11(10):1076-1084.
13. Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity.

Pediatr Obes. 2012;7(4):284-294.
14. McCarthy HD, Jarrett KV, Crawley HF. The development of waist circumference percentiles in British children aged 5.0-16.9 y. *Eur J Clin Nutr*. 2001;55(10):902-907.
15. Riddoch CJ, Mattocks C, Deere K, et al. Objective measurement of levels and patterns of physical activity. *Arch Dis Child*. 2007;92(11):963-969.
16. Riddoch CJ, Bo Andersen L, Wedderkopp N, et al. Physical activity levels and patterns of 9- and 15-yr-old European children. *Med Sci Sports Exerc*. 2004;36(1):86-92.
17. Mattocks C, Ness A, Leary S, et al. Use of accelerometers in a large field-based study of children: protocols, design issues, and effects on precision. *J Phys Act Health*. 2008;5(Suppl 1):S98-S111.
18. Esliger DW, Copeland JL, Barnes JD, Tremblay MS. Standardizing and optimizing the use of accelerometer data for free-living physical activity monitoring. *J Phys Act Health*. 2005;3:366-383.
19. Evenson KR, Catellier DJ, Gill K, et al. Calibration of two objective measures of physical activity for children. *J Sports Sci*. 2008;26(14):1557-1565.
20. Department of Health and Children, Health Services Executive. The National Guidelines on Physical Activity for Ireland. 2009. Available at: www.health.gov.ie/wp-content/uploads/2014/03/active_guidelines.pdf. Accessed September 12, 2015.
21. Heinen MM, Murrin C, Daly L, et al. *The Childhood Obesity Surveillance Initiative (COSI) in the Republic of Ireland: Findings from 2008, 2010, 2012 and 2015*. Dublin, Ireland: Health Services Executive; 2017. Available at: http://www.hse.ie/eng/about/Who/healthwellbeing/Our-Priority-Programmes/HEAL/HEAL-docs/COSI-in-the-Republic-of-Ireland-Findings-from-2008-2010-2012-and-2015.pdf. Accessed December 20, 2017.
22. Ahrens W, Pigeot I, Pohlabeln H, et al. Prevalence of overweight and obesity in European children below the age of 10. *Int J Obes (Lond)*. 2014;38(Suppl 2):S99-S107.
23. Savva SC, Tornaritis M, Savva ME, et al. Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. *Int J Obes Relat Metab Disord*. 2000;24(11):1453-1458.
24. Cooper A, Goodman A, Page A, et al. Objectively measured physical activity and sedentary time in youth: the international children's accelerometry database (ICAD). *Int J Behav Nutr Phys Act*. 2015;12(1):113.
25. Brage S, Wedderkopp N, Ekelund U, et al. Features of the metabolic syndrome are associated with objectively measured physical activity and fitness in Danish children: the European Youth Heart Study (EYHS). *Diabetes Care*. 2004;27(9):2141-2148.
26. Troiano RP, Berrigan D, Dodd KW, et al. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc*. 2008;40(1):181-188.
27. Pate RR, Wang CY, Dowda M, et al. Cardiorespiratory fitness levels among US youth 12 to 19 years of age: findings from the 1999-2002 National Health and Nutrition Examination Survey. *Arch Pediatr Adolesc Med*. 2006;160(10):1005-1012.
28. Trost SG, Pate RR, Sallis JF, et al. Age and gender differences in objectively measured physical activity in youth. *Med Sci Sports Exerc*. 2002;34(2):350-355.
29. Tremblay MS, LeBlanc AG, Kho ME, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *Int J Behav Nutr Phys Act*. 2011;8:98-98.
30. Rush E, Reed PW, Simmons D, et al. Baseline measures for a school-based obesity control programme: Project Energize: differences by ethnicity, rurality, age and school socio-economic status. *J Paediatr Child Health*. 2013;49(4):E324-E331.
31. Jin Y, Jones-Smith JC. Associations between family income and children's physical fitness and obesity in California, 2010–2012. *Prev Chronic Dis*. 2015;12:E17.
32. Lawlor DA, Harro M, Wedderkopp N, et al. Association of socioeconomic position with insulin resistance among children from Denmark, Estonia, and Portugal: cross sectional study. *BMJ*. 2005;331(7510):183.
33. Ward M. *Exploring the Predictors of Socio-economic Variation in Child Overweight and Obesity in Ireland: A Sociological Analysis*. Dublin, Ireland: Department of Children and Youth Affairs; 2015.
34. Shrewsbury V, Wardle J. Socioeconomic status and adiposity in childhood: a systematic review of cross-sectional studies 1990–2005. *Obesity*. 2008;16(2):275-284.
35. Sandberg K, Ji H. Sex differences in primary hypertension. *Biol Sex Differ*. 2012;3(1):1-21.
36. Colhoun HM, Hemingway H, Poulter NR. Socio-economic status and blood pressure: an overview analysis. *J Hum Hypertens*. 1998;12(2):91-110.
37. Grotto I, Huerta M, Sharabi Y. Hypertension and socioeconomic status. *Curr Opin Cardiol*. 2008;23(4):335-339.
38. Leary SD, Ness AR, Smith GD, et al. Physical activity and blood pressure in childhood: findings from a population-based study. *Hypertension*. 2008;51(1):92-98.
39. Kelly LA, Reilly JJ, Fisher A, et al. Effect of socioeconomic status on objectively measured physical activity. *Arch Dis Child*. 2006;91(1):35-38.
40. Beckvid Henriksson G, Franzén S, Elinder LS, Nyberg G. Low socioeconomic status associated with unhealthy weight in six-year-old Swedish children despite higher levels of physical activity. *Acta Paediatr*. 2016;105(10):1204-1210.
41. Brockman R, Jago R, Fox KR, et al. "Get off the sofa and go and play": family and socioeconomic influences on the physical activity of 10-11-year-old children. *BMC Public Health*. 2009;9:253.
42. McDonald NC. Active transportation to school: trends among U.S. schoolchildren, 1969-2001. *Am J Prev Med*. 2007;32(6):509-516.
43. Freitas D, Maia J, Beunen G, et al. Socio-economic status, growth, physical activity and fitness: the Madeira Growth Study. *Ann Hum Biol*. 2007;34(1):107-122.
44. Jimenez-Pavon D, Ortega FB, Ruiz JR, et al. Influence of socioeconomic factors on fitness and fatness in Spanish adolescents: the AVENA study. *Int J Pediatr Obes*. 2010;5(6):467-473.
45. Gordon-Larsen P, Nelson MC, Page P, Popkin BM. Inequality in the built environment underlies key health disparities in physical activity and obesity. *Pediatrics*. 2006;117(2):417-424.