Effect of socioeconomic status on objectively measured physical activity

L A Kelly, J J Reilly, A Fisher, C Montgomery, A Williamson, J H McColl, J Y Paton, S Grant

Background: A socioeconomic gradient in childhood obesity is known to be present by the age of school entry in the UK. The origin of this gradient is unclear at present, but must lie in socioeconomic differences in habitual physical activity, sedentary behaviour, or dietary intake.

Aims: To test the hypothesis that habitual physical activity and/or sedentary behaviour are associated with socioeconomic status (SES) in young Scottish children.

Methods: Observational study of 339 children (mean age 4.2 years, SD 0.3) in which habitual physical activity and sedentary behaviour were measured by accelerometry over six days (study 1). In a second study, 39 pairs of children of distinctly different SES (mean age 5.6 years, SD 0.3) were tested for differences in habitual physical activity and sedentary behaviour by accelerometry over seven days.

Results: In study 1, SES was not a significant factor in explaining the amount of time spent in physical activity or sedentary behaviour between affluent and deprived groups.

Conclusion: Results do not support the hypothesis that low SES in young Scottish children is associated with lower habitual physical activity or higher engagement in sedentary behaviour.
distinct types of primary school: local authority (for Carstairs groups 6 and 7) and private sector schools (for Carstairs groups 1 and 2). Recruitment of children in this way not only facilitated selection of two distinct socioeconomic groups, but the differences in education (local authority versus private) reinforced the impression that these two groups were actually socioeconomically distinct. Recruitment produced 116 children potentially available for inclusion. We included all children in deprivation categories 1 and 2 (affluent group) and deprivation categories 6 and 7 (deprived group) whom we could match pair-wise for gender and school days/school holidays; our sample consisted of 78 children (39 pairs; 20 pairs of girls, 19 pairs of boys; mean age 5.6 years, SD 0.4) for study 2, all of whom provided at least six hours of accelerometer per day over seven days during November.

For both studies 1 and 2, all children were apparently healthy, with no chronic disease relevant to energy balance or physical activity. The studies were approved by the Yorkhill Hospitals Ethics Committee. Informed written consent was obtained from the parent/guardian of each child.

Measurements of habitual physical activity and sedentary behaviour

In study 1 we measured physical activity and sedentary behaviour objectively over six days during the waking hours (mean duration of measurement 54.9 hours, SD 13.8) using accelerometers. In study 2 we measured the same variables over seven days using the same methods (mean duration of measurement 73.9 hours, SD 12.3). In both studies we asked families to attach the accelerometers when the children woke up, to remove them when they went to bed, and to record when and why they were removed at other times. The accelerometers were set to monitor activity in one minute sampling intervals (epochs) as previously described.12 These activity monitoring periods exceed the time required to determine usual physical activity and sedentary behaviour.11 We have previously observed negligible day-to-day variation (for example, weekday–weekend variation) in accelerometer output in our samples of young children in Scotland, and no systematic within-child, within-day variation in accelerometer output (time of day effects).11 Accelerometry count averaged over the monitoring period (count per minute, cpm) was used as an index of total physical activity;11 14 we also calculated percentage of monitored time spent sedentary (no trunk movement, <1100 cpm),13 and percentage of monitored time in moderate–vigorous physical activity (MVPA; >3200 cpm*). These definitions or “cut points” for accelerometer output have been validated against both energy expenditure12 and direct observation of behaviour12 in previous studies.

Statistical analysis

Study 1

Analysis of variance and covariance models were used to assess the effect of the following explanatory variables on mean accelerometer output (cpm): age; BMI SD score; gender; SES; month of measurement. For each of these variables separately a univariate analysis was carried out. A final multivariate model was obtained by backward stepwise elimination from a model including all the five explanatory variables.

Study 2

Since study 2 used a paired design we tested differences between the two SES groups for significance using paired statistical methods. Our power calculation estimated that (with a paired design) a mean difference in total physical activity of around 100 cpm between groups would be detectable with 90% power at a significance 0.05, in 38–40 pairs of children. This magnitude of difference is approximately 10–15% of accelerometer output since this usually averages 700–800 cpm.12 14 17 For context, this difference in physical activity is of a similar magnitude to that typically observed between the sexes at this age.13 14 17

RESULTS

Physical characteristics of subjects, levels of physical activity, and sedentary behaviour

The physical characteristics of children in both studies 1 and 2 are shown in table 1.

Study 1: Factors influencing physical activity

The results of the analysis are shown in table 2. A univariate analysis found that mean accelerometer output (cpm) was significantly lower in the most affluent SES group compared to the other two groups, but this association did not persist once other variables were taken into account in the multivariate analysis. Only gender and month of measurement were included in the final model in study 1. Total physical activity was significantly higher in boys than girls, and significantly higher in September than October.

Study 2: Differences in total physical activity between socioeconomic groups

Total physical activity (accelerometer, cpm) did not differ significantly on average for affluent and deprived participants. Mean accelerometer count per minute in the affluent participants was 734 cpm (SD 151) compared with 793 cpm (SD 196) for the deprived participants (paired t test, p = 0.10). There were also no statistically significant differences in total physical activity between affluent and deprived participants when considered separately by gender (p > 0.05 in each case).

Study 2: Differences in moderate–vigorous intensity physical activity between socioeconomic groups

Median percentage of monitored time spent in moderate to vigorous intensity activity (MVPA) was identical in the affluent and deprived participants: 3% (range 1–7) versus 3% (range 1–9) respectively.

Study 2: Differences in sedentary behaviour between socioeconomic groups

Median percentage of monitored time spent in sedentary behaviour was not significantly different for the two groups (affluent participants, 79% (range 68–90) versus deprived participants, 78% (range 67–89); Wilcoxon sign rank test, p = 0.13).

When data were analysed separately by gender, we found that in boys, percentage time spent in sedentary behaviour was significantly lower in the deprived than the affluent group (Wilcoxon sign rank test, p = 0.01). For all other analyses of physical activity and sedentary behaviour, results did not differ when analysed with the entire group or by gender.

**Table 1** Characteristics of participants, physical activity, and sedentary behaviour

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Study 1 (n = 339)</th>
<th>Study 2 (n = 78)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>4.2 (0.3)</td>
<td>5.6 (0.4)</td>
</tr>
<tr>
<td>BMI SD score</td>
<td>0.40 (0.89)</td>
<td>0.61 (0.73)</td>
</tr>
<tr>
<td>% time spent sedentary*</td>
<td>77 (53–93)</td>
<td>78 (67–90)</td>
</tr>
<tr>
<td>% time spent in moderate–vigorous physical activity*</td>
<td>3 (0–13)</td>
<td>3 (1–9)</td>
</tr>
</tbody>
</table>

Results expressed as mean (SD).

*Variables with skewed distribution, so median (range) given.
DISCUSSION
In the present study we found no evidence of marked differences in either habitual physical activity or sedentary behaviour between SES groups. Thus, our observations do not support the hypotheses that more deprived children are less physically active or more sedentary than more affluent children, despite marked differences in obesity risk associated with SES. Our failure to observe differences in children, despite marked differences in obesity risk asso-
ciated with SES. Our failure to observe differences in either habitual physical activity or sedentary behaviour between SES groups. Thus, our observations do not support the hypotheses that more deprived children are less physically active or more sedentary than more affluent children, despite marked differences in obesity risk associated with SES. Our failure to observe differences in children, despite marked differences in obesity risk asso-

It is possible that there are differences in habitual physical activity between ethnic groups in the UK, or that relations between physical activity and adiposity might differ between ethnic groups, or between boys and girls. Children who participated in the present studies were almost entirely from the majority ethnic group in Scotland, and so we could not address the issue of ethnicity. We found evidence that social patterning of sedentary behaviour might differ between boys and girls in study 2, but this needs to be confirmed in future studies in other samples and settings. One recent study found a possible gender difference in the relation between physical activity and adiposity in 7 year old British children.

In the present studies, we used a uniaxial accelerometer (designed to measure activity predominantly in the vertical plane). While in theory measurement in two or three planes of movement might provide greater accuracy, empirical studies comparing uniaxial versus biaxial or triaxial accelerometry do not support this. We summarised accelero-
meter output in one minute measurement intervals (epochs). In theory, shorter epochs might provide more accurate quantification of more vigorous activities, but again empirical tests do not support this hypothesis, and use of shorter measurement intervals does not provide an advantage in practice. The main practical impact of this approach to the interpretation of accelerometry output appears to be a small systematic misclassification of some vigorous activity as moderate intensity activity; this is one reason why we summarised both categories in combination.

Conclusions
The results of the present studies are not consistent with the hypothesis that differences in physical activity or sedentary behaviour underlie socioeconomic variations in obesity risk in early childhood. The present study leads to the prediction that socioeconomic differences in dietary intake underlie the social patterning of obesity in young British children.

ACKNOWLEDGEMENTS
Study 1 was funded by the British Heart Foundation. We thank Glasgow City Council for their support, the schools who helped with recruitment to study 2, and the parents and children who took part for their enthusiastic participation.

Table 2 Analysis of variance and covariance for study 1 (total physical activity, mean accelerometer count per minute)

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>Univariate analysis</th>
<th>Multivariate analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient (ESE)</td>
<td>p value</td>
</tr>
<tr>
<td>Gender, female v male</td>
<td>–62.0 (20.7)</td>
<td>0.003</td>
</tr>
<tr>
<td>Month (Oct v Sept)</td>
<td>–83.9 (20.7)</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>SES, 1 v 3</td>
<td>–124.5 (44.6)</td>
<td>0.02</td>
</tr>
<tr>
<td>SES, 2 v 3</td>
<td>–1.8 (23.6)</td>
<td>NS</td>
</tr>
<tr>
<td>Age (years)</td>
<td>16.3 (30.1)</td>
<td>NS</td>
</tr>
<tr>
<td>BMI SD score</td>
<td>17.4 (11.2)</td>
<td>NS</td>
</tr>
</tbody>
</table>

R² for final model, 7.0%. ESE, estimated standard error; NS, not significant.
What is already known on this topic

- Children from more socioeconomically deprived families are at much greater risk of obesity than those from wealthier families
- The reasons for this social patterning in childhood obesity are unclear, but must lie in socioeconomic differences in physical activity, dietary intake, or both

What this study adds

- Habitual physical activity is not influenced by socioeconomic status
- Socioeconomic differences in obesity risk are likely to be due to social patterning of dietary intake

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Competing interests: none

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