Ethnic differences in growth in early childhood: an investigation of two potential mechanisms

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Background: There are clear ethnic differences in birthweight. This study examines whether and how these disparities are replicated in a later marker of physical development, height at 5 years. Methods: Observational data from the UK Millennium Cohort Study, constructed to over-represent ethnic minority (Indian, Pakistani, Bangladeshi, Black African, Black Caribbean and Other) children. Results: Mean birthweight of ethnic minority children was lower than that of the ethnic majority (3.06–3.34 kg vs. 3.41 kg), but ethnic minority children were not shorter at 5 years. Pakistani, Caribbean and African children were actually taller on average (by 0.5 cm, 1.4 cm and 3.5 cm). Controlling for parental height and birthweight did not affect height differentials. Two mechanisms were hypothesized: (i) a cramped intrauterine environment given the short stature of some minority children’s mothers resulted in catch-up growth; and (ii) conditions during the parents’ childhood led to a reduced capacity to reach their height potential. A reparameterization of parent heights showed that mother’s height contributed more to predicting child height than joint parental height alone. Birthweight was positively related to height and attenuated the extra contribution from mothers’ heights. Decomposing the effects into their constituent parts found some support for both hypotheses. Conclusions: These results suggest that children from ethnic minority backgrounds are not disadvantaged with respect to height growth compared with the ethnic majority. However, if adiposity is more likely when children are tall for their age, then ethnic inequalities in adult health could increase as the current generation of children mature.
Introduction

Low birthweight is known to be associated with adverse health outcomes in later life, including heart disease, stroke, high blood pressure, metabolic syndrome and insulin resistance.\(^1\)\(^-\)\(^10\) People from minority ethnic groups are both more likely to report ill-health,\(^1\)\(^1\)\(^12\) and have a greater risk of low birthweight and of obesity in childhood.\(^13\)\(^-\)\(^15\) If we want to understand more about the developmental origins of ethnic inequalities in adult weight in ethnic minority babies,\(^16\)\(^-\)\(^22\) Some argue that lower birthweight is normative among ethnic minority groups while others suggest that low birthweight is an indication of poor intrauterine growth.

If lower mean birthweight has genetic origins, one might expect ethnic minority groups to continue to be smaller throughout life. The evidence based on adult height is mixed. Bangladeshi, Indian, Pakistani and Black African men and women are shorter than average in England.\(^11\) Black Caribbean men and women and Black African women are a similar height to their same sex peers. However, age stratification shows a trend of increased height in younger cohorts suggesting that the height disadvantage of some minority groups may be narrowing and could ultimately disappear. Inter-generational differences in height might be more marked in minority groups where childhood conditions of earlier born generations prevented them from reaching their height potential.\(^23\)\(^,\)\(^24\)

Alternatively, lower birthweight within ethnic minority groups may follow from findings that shorter mothers provide a more physically constrained intrauterine environment. Ethnic minority mothers are more likely to be short and so their children are at greater risk of low birthweight. Children whose prenatal growth is restricted exhibit some post-natal catch-up.\(^25\)\(^,\)\(^26\)

Both hypotheses predict that ethnic minority children growing up in the UK may not be at a height disadvantage but the mechanisms are quite different. Recent work by Griffiths et al.\(^27\) suggests a way to disentangle these influences. They examined the relationship between parental and child anthropometric measures by estimating the joint contribution from both parents and the excess maternal contribution. The joint parental contribution is said to capture intergenerational, including genetic, effects while additional maternal contributions capture environmental and epigenetic influences.\(^28\)

Accordingly, aims of this study are to: (i) investigate ethnic differences in height at 5 years; (ii) examine mechanisms suggested by the height potential and catch-up growth hypotheses within the ethnic groups; and (iii) investigate potential ethnic disparities in these mechanisms. Oaxaca decomposition is applied to the regression models to address the latter two aims.\(^29\)

Methods

The Millennium Cohort Study (MCS) is a nationally representative longitudinal study of infants born in the UK. The sample was drawn from births between September 2000 and January 2002 selected on the basis of place of residence shortly after the time of birth, with over-representation of disadvantaged residential areas (\(n = 18,552\), 85\% response). Further details are described elsewhere.\(^30\) The first three sweeps of the survey involved home interviews when cohort members were \(~\sim\) 9 months, 3 years and 5 years. Self-reported anthropometric measures were provided at each interview. At the third visit, child and parental anthropometric measurements were taken by trained interviewers. Ethical permission for the survey was obtained by the original investigators prior to data collection. Parents gave informed consent before interviews took place, with separate written consent for anthropometry.

Ethnic group was derived from the 2001 UK census question into the following groups: White British, Indian, Pakistani, Bangladeshi, Black Caribbean, Black African and Other. To prevent problems with small cell sizes, mixed Caribbean and White and mixed African and White ethnicity were categorized as Caribbean and African. Mixed South Asian and White ethnicity was categorized as Other.

Natural mothers’ and fathers’ height were standardized using the mean (women 164.10 cm; men 178.42 cm) and SD (women 6.91 cm; men 7.23 cm) for the full MCS sample.

Child birthweight in kilograms was asked of the main respondent (98\% mothers) at the first survey. Birthweight was converted to a standardized z-score based on the mean (3.38 kg) and SD (0.57 kg) for the full MCS sample.

Children’s height and their age in months at the time of assessment were recorded by the interviewers at the third survey when the children were \(~\sim\) 5 years old. Height was converted to a standardized z-score based on the WHO Child Growth Standards,\(^31\)\(^,\)\(^32\) that depict height for sex and age ‘under optimal environmental conditions and can be used to assess children everywhere, regardless of ethnicity, socio-economic status and type of feeding’.

We excluded cohort members who were not singletons (256), had unknown ethnicity (31), had dropped out of the study before sweep three (3813) or had missing data for child height (457) or birthweight (43). The sample of parent–child triads available for analysis numbered 13,955. Missing data for maternal height (116) and paternal height (3723) were filled-in based on the Health Survey for England (HSE) ethnic and sex-specific norms under the assumption that parental data were missing completely at random (MCAR). Height norms were calculated using data from the HSE 1998, 1999 and 2004 surveys.\(^1\)\(^1\)\(^12\)\(^,\)\(^29\) Normative height estimates stratified by ethnic group were derived for female adults aged 16–44 years and male adults aged 16–54 years. Norms for the other group used the overall mean for men and women in these age ranges.

Data analysis

Ethnic differences in mean child and parental anthropometrics were assessed using analysis of variance. Multivariate linear regression models are based on cases with complete data on relevant variables. All analyses take account of the clustered sample design and the unequal probability of being sampled. We use Griffiths et al.’s\(^27\) method to reparameterise parental height, providing regression estimates that are the sum and the difference of the coefficients estimated with separate maternal and paternal variables. The reparameterization involves constructing the sum of maternal and paternal height z-scores and half the difference of the two z-scores, giving

\[
y = \beta_0 + \beta_1(x_1 + x_2) + \beta_2(x_1 - x_2)/2
\]

where \(y\) is the child’s height z-score, \(x_1\) is the father’s height z-score and \(x_2\) is the mother’s height z-score (see Supplementary Appendix A1 for details).

Results are stratified by ethnicity after preliminary analyses (not shown) found interactions for joint parental contribution (\(F_{6,384} = 2.36\), \(P = 0.03\)) and additional maternal contribution (\(F_{6,384} = 2.11\), \(P = 0.05\)) with ethnicity. Differences between ethnic minority groups and the White group are explained using Oaxaca decomposition.\(^29\)\(^33\) Taking the Indian and White groups as an example, from (1) we have

\[
\gamma_{\text{Indian}} - \gamma_{\text{White}} = \beta_{\text{Indian}} - \beta_{\text{White}}
\]

where \(\beta\) is a column vector of coefficients and \(x\) is a row vector of the means of the explanatory variables. Equation (2) can be rearranged into

\[
\gamma_{\text{Indian}} - \gamma_{\text{White}} = (x_{\text{Indian}} - x_{\text{White}})\beta_{\text{White}}
\]

\[
+ (x_{\text{Indian}} - x_{\text{White}})(\beta_{\text{Indian}} - \beta_{\text{White}})
\]

\[
+ (x_{\text{Indian}} - x_{\text{White}})(\beta_{\text{Indian}} - \beta_{\text{White}})
\]

\[
= E + C + CE
\]

Thus, the gap in mean height between ethnic minority and the majority group is decomposed into two parts. The first is that explained by group differences in the ‘magnitudes’ of the determinants of height (endowments, \(E\)), the second is that which is unexplained because of (i) differences in the ‘impact’ of the determinants (coefficients, \(C\)), (ii) simultaneous differences in endowments and coefficients (interaction, \(CE\)), and (iii) potential differences in unobserved variables.
Sensitivity analyses (data not shown) tested the assumption that parental data were MCAR, finding no substantive differences with the results below.

Results

Descriptive characteristics of the study population

Table 1 shows the anthropometric characteristics of MCS children and their parents. South Asian mothers were shorter than White mothers, especially Bangladeshi mothers (1.57 m vs. 1.64 m). African and Caribbean mothers were slightly taller than the White group; by ~1 cm. Fathers in all the ethnic minority groups were shorter on average than White fathers (1.79 m), ranging from 2 cm (Caribbean) to 9 cm (Bangladeshi) less.

Mean birthweight in each ethnic minority group was lower than in the White group. Indian and Bangladeshi babies were smallest, being on average 0.25 kg lighter than White babies. In contrast to their parents, Indian, Pakistani, Caribbean and African children were taller than White children aged 5 years although the Other group were smaller. There was no height disadvantage for the Bangladeshi group despite their parents being shortest overall. All reported differences are statistically significant.

Association between parental and child height

Table 2 shows the association between parental height and child height, standardized by age and sex. Model 1 shows that the mean parental height coefficient predicts child height in all ethnic groups. A 1 SD increase in mean parental height (~7 cm) is associated with an increase in child height ranging from 0.31 standard deviations (1.5 cm) for Pakistani children to 0.53 standard deviations (2.5 cm) among Indian children. With the exception of Bangladeshi children, the difference in height coefficient is positive, showing that maternal height contributed more to explaining the variance in child height than paternal height. However, the effects were small in the Indian and Other groups. Birthweight was a weak to moderate predictor of height in White, Pakistani, Bangladeshi, African and Other children (Model 2). The difference between the parental height contributions is attenuated somewhat after controlling for birthweight in the White, Caribbean and African but not the Pakistani group.

Decomposition of models in comparison to the White British group

Figure 1 shows the decomposition of Model 2 by ethnic group into explained effects, E and figure 2 shows the unexplained effects, C + CE.

Effects shown above the horizontal favour minority children and elucidate why they are taller than White British children. Effects below the horizontal indicate the opposite—that the value of endowments, coefficients or their interaction favour White British children and predict the minority group should be shorter than White British children.

If ‘endowments’ are inconsistent with the height gaps (favour White British children) then there is weak support for the height potential and catch-up growth hypotheses (e.g. figure 1, Indian). If differences in the joint parental height ‘coefficient’ favour minority children then there is stronger support for the parental growth potential hypothesis (figure 2, Pakistani). The catch-up growth hypothesis is more strongly supported if the ‘difference in height’ or birthweight ‘coefficients’ favour minority children (figure 2, Bangladeshi). Differences in the intercept ‘coefficients’ represent unknown mechanisms (figure 2, Caribbean).

The model predicts that on average Indian children are marginally taller than White children (ΔIndian = 0.14). The decomposition indicates that differences in joint parental height favour the White group. In other words, inter-generational endowments predict that Indian children should have been smaller than White children. Unexplained differences favour the Indian group but the mechanisms are unknown. The explanation why Indian children are not smaller than White children lies elsewhere.

For both Pakistani and Bangladeshi groups, anthropometric endowments also favour White children. The breakdown shows that differences in joint parental height and birthweight predict that Pakistani and Bangladeshi children should be shorter than their White peers. For Bangladeshi and to lesser extent Pakistani children, there are unexplained differences favouring the minority group, contributing to them being taller than expected given their anthropometric characteristics. The decomposition finds that the impact of joint parental height favours Pakistani children, whereas the impact of the additional contribution of maternal stature favours White British children over Bangladeshi children.

The mean predicted height of Caribbean and African children is greater than that of White children (ΔCaribbean = 0.29; ΔAfrican = 0.74). Anthropometric endowments do not favour any group but the detailed decomposition tells a more differentiated story. The magnitude of joint parental height and birthweight (African only) favour the White group but the additional contributions of maternal stature favour the minority groups. Differences in coefficients also favour Caribbean and African children, especially the latter. Decomposing further, disparities in the intercepts show that their height advantages are also due in part to unmeasured factors.

For the heterogeneous Other group, total differences in endowments and in coefficients cancel each other out to produce no difference in predicted height compared with White children. Joint parental height and birthweight endowments favour the White group but unexplained effects favoured the Other group. There are no hints as to the source of the unexplained influences on these children’s height.
### Table 2: Linear regression estimates with 95% confidence intervals for height-for-age z-score at sweep 3 by ethnic group

<table>
<thead>
<tr>
<th>Ethnic Group</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>95% CI</td>
</tr>
<tr>
<td>White British (n = 11730)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.02</td>
<td>−0.01 to 0.04</td>
</tr>
<tr>
<td>Mean parental height coefficient</td>
<td>0.25</td>
<td>0.24 to 0.26</td>
</tr>
<tr>
<td>Difference in height coefficients</td>
<td>0.18</td>
<td>0.15 to 0.20</td>
</tr>
<tr>
<td>Birth weight z-score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$r^2$</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>Indian (n = 375)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.46</td>
<td>0.30 to 0.63</td>
</tr>
<tr>
<td>Mean parental height coefficient</td>
<td>0.27</td>
<td>0.18 to 0.36</td>
</tr>
<tr>
<td>Difference in height coefficients</td>
<td>0.18</td>
<td>−0.01 to 0.36</td>
</tr>
<tr>
<td>Birth weight z-score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$r^2$</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>Pakistani (n = 638)</td>
<td></td>
<td></td>
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<tr>
<td>Constant</td>
<td>0.23</td>
<td>0.13 to 0.34</td>
</tr>
<tr>
<td>Mean parental height coefficient</td>
<td>0.15</td>
<td>0.11 to 0.20</td>
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<tr>
<td>Difference in height coefficients</td>
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<td>0.13 to 0.31</td>
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<tr>
<td>Birth weight z-score</td>
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<tr>
<td>$r^2$</td>
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<tr>
<td>Bangladeshi (n = 250)</td>
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<tr>
<td>Constant</td>
<td>0.47</td>
<td>0.07 to 0.87</td>
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<tr>
<td>Mean parental height coefficient</td>
<td>0.18</td>
<td>0.06 to 0.30</td>
</tr>
<tr>
<td>Difference in height coefficients</td>
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<td>−0.35 to 0.19</td>
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<tr>
<td>Birth weight z-score</td>
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<td></td>
</tr>
<tr>
<td>$r^2$</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>Black Caribbean (n = 312)</td>
<td></td>
<td></td>
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<tr>
<td>Constant</td>
<td>0.32</td>
<td>0.16 to 0.48</td>
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<tr>
<td>Mean parental height coefficient</td>
<td>0.21</td>
<td>0.13 to 0.28</td>
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<tr>
<td>Difference in height coefficients</td>
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<td>0.06 to 0.37</td>
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<tr>
<td>Birth weight z-score</td>
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<td></td>
</tr>
<tr>
<td>$r^2$</td>
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<td></td>
</tr>
<tr>
<td>Black African (n = 302)</td>
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<td>Constant</td>
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<td>Mean parental height coefficient</td>
<td>0.17</td>
<td>0.09 to 0.26</td>
</tr>
<tr>
<td>Difference in height coefficients</td>
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<td>0.09 to 0.48</td>
</tr>
<tr>
<td>Birth weight z-score</td>
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<td></td>
</tr>
<tr>
<td>$r^2$</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Other (n = 346)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.23</td>
<td>0.06 to 0.39</td>
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<tr>
<td>Mean parental height coefficient</td>
<td>0.23</td>
<td>0.17 to 0.30</td>
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<tr>
<td>Difference in height coefficients</td>
<td>0.08</td>
<td>−0.09 to 0.25</td>
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<tr>
<td>Birth weight z-score</td>
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<td></td>
</tr>
<tr>
<td>$r^2$</td>
<td>0.15</td>
<td></td>
</tr>
</tbody>
</table>

*a*: All estimates are weighted to take account of the stratified sample and confidence intervals allow for clustering

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**Figure 1**: Contribution of explained differences in endowments to ethnic differences in mean height z-scores in comparison with the White British group from linear regression Model 2. *P < 0.05; **P < 0.005; ***P < 0.0005
Discussion

Main findings

Ethnic minority children in the UK are not at a height disadvantage compared with the white majority. This contrasts with evidence on their parents’ generation and their own circumstances at birth. We found no evidence in the decompositions that the magnitude of their anthropometric endowments explained the height advantage of ethnic minority children: most of the height advantage of the minority groups could not be attributed to factors included in the models. Rather, the converse was true: explained differences favoured White British children in every case. If the effect of anthropometric endowments were the same in all groups then the ethnic minority children would have been shorter than White British children.

It was joint parental height ‘values’ that favoured the White group over all ethnic minority groups. This is consistent with the growth potential hypothesis, but evidence on joint parental height ‘coefficients’ provides more support. This favoured Pakistani children, indicating that small parental stature had less of an impact on their children’s height than that seen for White families. We would expect this if Pakistani parents had failed to reach their growth potential.

Maternal height favoured black African and Caribbean children since their mothers were taller on average than White mothers, suggesting environmental conditions did not lead to growth restriction in their babies. The effect of maternal height did not favour growth in Bangladeshi children which also appears inconsistent with the catch-up growth hypothesis. Consistent with catch-up growth, differences in the impact of birthweight, while imprecise, favoured Bangladesh over White children. Birthweight endowments also favoured the White group when contrasted with Pakistani, Bangladeshi, African and Other groups. Holding all else equal, the minority children should have been shorter given their size at birth. Birthweight appears to be a better marker of growth insufficiency than maternal height in ethnic minority children and provides some support for the catch-up growth hypothesis.

The relationship between birthweight and adult health appears especially strong if accompanied by increased adiposity in adulthood. In adulthood, obesity is associated with shorter stature but in childhood adiposity is positively correlated with height and taller children are more likely to still be overweight or obese in adulthood. If adiposity is more likely when children are tall for their age, then Caribbean and African children may be at particular risk of later cardiovascular morbidity.

The discourse around ethnic inequalities in health mainly suggests economic, psychosocial and cultural factors disadvantage minority groups. The current findings do not lend themselves to similar explanations. The minority children are living in poorer socio-economic conditions on average than the majority White group, and yet they are growing well. Obesity could account for this paradox. It is also possible that it is not minority children who are taller than expected but White children who are not as tall as expected. The data support this interpretation: a White 5-year-old born at mean birthweight to parents of mean height is >5 cm shorter than a child born under optimal environmental conditions according to the WHO Child Growth Standards. The better health behaviours (smoking during pregnancy, breastfeeding practices, diet and physical activity) in ethnic minority groups could partially explain these findings.

Strengths and limitations

Data on birthweight were collected when infants were 9 months old, with the potential for recall bias. However, maternal recall of birthweight has been shown to be reliable in other studies and the MCS data correspond well with birth registration data. Similarly, not all parental height was objectively measured but reporting bias is low in adults of child rearing age. The distribution of missing parental height data, especially maternal, differ by ethnicity but the sensitivity analyses showed that imputing parental height did not affect the results. The possible influence of maternal pre-pregnancy weight was considered but it was not related to child height once birthweight was accounted for. Unfortunately, parental migration history was too incomplete to allow us to assess the growth potential hypothesis more directly. We could not analyse children of mixed ethnicity separately so our results are likely to be conservative. Offset against these limitations is the advantage of a large nationally representative sample with over-sampling in areas with a high density of ethnic minority residents, enabling us to consider more nuanced ethnic identities.

Conclusion

Differences in height between ethnic groups do not mirror patterns for birthweight. Ethnic minority children are taller than expected given their
parents’ height and their own birthweight. There was some evidence that parents of ethnic minority children had failed to reach their growth potential and some evidence of catch-up growth in low birthweight minority children. However, it may be that the apparent height advantage of children from ethnic minority backgrounds may play out in unfavourable body weight trajectories with consequent risks for poor cardiovascular profiles in adult life.

Supplementary Data

Supplementary Data are available at EURPUB online.

Acknowledgements

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Conflicts of interest: None declared.

Key points
- Ethnic minority children are at greater risk of low birthweight and hence of adverse health outcomes in later life.
- Paradoxically, ethnic minority children are taller than the majority white population of children in the UK.
- There was some evidence of catch-up growth in low birthweight minority children and that they are reaching their height potential unlike their parents’ generation.
- These effects explain only a part of ethnic differences in height and other causes should be investigated.
- Since taller children are more inclined to obesity, the height advantage of ethnic minority children may not translate into a health advantage in adulthood.

References

Adolescent physical activity predicts high education and socio-economic position in adulthood

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Impact of adolescent physical activity on adulthood

Introduction

Physical activity (PA) in general and its high intensity in particular influences positively health and fitness,¹ reduces the risk of several diseases,²,³ promotes mental health and well-being⁴ and reduces stress,⁵ while lack of or minor PA is related to poor development of health⁶ and mental and social problems.⁷ Through its impact on a schoolchild’s health and vigour—and through that, on improved school performance—PA is a potential factor in the promotion of favourable educational and socio-economic careers during the life course and especially, in adolescence where the turbulence of puberty and increasing academic demands from school converge. In the debate of the influences of PA, this aspect has been of less interest.

Achievements at school may be a mediating factor between PA in childhood and favourable educational routes leading to high social and educational positions when reaching the adult age. Several studies have shown a positive association between PA and educational achievement.⁸,⁹ In his review of PA at school and academic outcomes, Taras¹⁰ concluded that there may be short-term improvements of determinants of school performance (such as improved concentration), but long-term improvements of academic achievement as a result of more vigorous PA, is not well substantiated.

Young people’s PA practices and educational performance are influenced by their living conditions. Children of higher social classes tend to be more physically active than their counterparts in lower social classes,¹¹–¹³ as well as more likely to do well at school and to attain high educational levels.¹⁴ When studying the association of PA in adolescence and the development of educational and socio-economic careers, socio-economic conditions of the family need to be taken into account.

The aim is to investigate the relationship of PA in adolescence with educational level and socio-economic position (SEP) in early adulthood. A potential mediating effect of school performance and the confounding effect of the childhood socio-economic background is analysed.

Methods

Study design and data

A longitudinal study design was constructed by combining data collected in 1981, 1983, 1985, 1987 and 1989 in the Adolescent Health and Lifestyle Survey (AHLS, Finland) with data from national registries. Nationally representative samples of 14- and 16-year-olds born within a specified range of birth dates in July 1964, 1966, 1968, 1970 and 1972 were drawn from each study year, from the Population Register Centre. The baseline population consisted of 13 446 persons, of whom 10 498 responded to the questionnaires and non-respondents to the single questions from 14 995 every resident.¹⁵ We excluded 125 baseline respondents who died during the follow-up (0.93% of the sample), as well as non-respondents to the questionnaires and non-respondents to the single questions from analyses concerning these questions.