RESEARCH REPORT

Childhood IQ in relation to risk factors for premature mortality in middle-aged persons: the Aberdeen Children of the 1950s study

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Objective: A series of studies have shown an association between high childhood IQ scores and reduced rates of total mortality in adulthood. Several mechanisms have been advanced to explain these relationships, including mediation via established risk factors. This study examines the association between childhood IQ and a range of established physiological and behavioural risk factors for premature mortality in adulthood.
Design, setting and participants: In 1962, 12 150 children took part in a school-based survey when their IQ scores were extracted from educational records. When re-surveyed forty years later (n = 7183; 63.7% response), they self-reported information on risk factors for premature mortality (smoking, heavy alcohol consumption, obesity, height, hypertension and diabetes).
Main results: In sex-adjusted analyses based on an analytical sample of 5340 (2687 women), higher childhood IQ scores were associated with a decreased prevalence of ever having smoked regularly in adulthood ($OR_{\text{per SD increase in IQ}}$ (95% CI): 0.77 (0.73 to 0.81)), heavy alcohol consumption (0.89 (0.84 to 0.94)), obesity (0.78 (0.72 to 0.83)) and overweight (0.86 (0.81 to 0.91)). Higher IQ scores were similarly related to a reduced prevalence of short stature and higher rates of smoking cessation in smokers; effects that were stronger in women (p value for interaction: $\leqslant 0.04$). Adjusting for indicators of early and, particularly, later-life socioeconomic circumstances led to heavy attenuation of these gradients with statistical significance at conventional levels lost in most analyses.
Conclusions: The IQ–risk factor gradients reported may offer some insights into the apparent link between high pre-adult IQ and reduced mortality rates.

First introduced about a century ago, psychometric tests of cognitive ability (IQ tests) have been most commonly used in educational and workplace settings.[1] However, in the past 5 years the association of IQ test scores with chronic disease and mortality has been examined in the recently established field of cognitive epidemiology.[2] Findings from population-based prospective cohort studies indicate that childhood IQ is associated with all-cause mortality,[3–8] coronary heart disease (CHD),[9–11] and possibly some cancers[5] in adulthood. Thus, in comparison with their lower scoring peers, children with higher test results have a reduced risk of these outcomes in later life. The consistency of these findings, particularly for IQ in relation to total mortality, has prompted speculation as to the mechanisms involved. These include the influence of early-life IQ on adult risk factors for premature mortality and chronic disease that may mediate the IQ–mortality gradient.[3 12–14]

Established risk factors for all-cause mortality and major chronic disease, such as CHD and selected cancers, include smoking,[15] heavy alcohol consumption,[16 17] obesity and overweight,[15 18 19] reduced stature,[20] raised blood pressure,[15 21 22] and diabetes.[15 23 24] In a cohort drawn from the west of Scotland, there was a suggestion that early IQ was associated with smoking cessation but not uptake.[25] In a separate report from the same study,[26] and also in a Swedish birth cohort,[27] higher IQ scores in childhood seemed to confer protection against high blood pressure in adulthood, although the effects were modest. In the only exploration of the influence of IQ on heavy alcohol consumption there was no apparent association in a group of Danish conscripts,[28] although in the Aberdeen Children of the 1950s study we found that self-reported alcohol-induced hangovers were less common in adults who, as children, had better IQ test performance.[29] For the most examined risk factor, obesity, the relationship with IQ is inconsistent across a number of studies.[5 30–34]

The few studies that have examined the IQ–risk factor link are subject to limitations, which hamper data interpretation. Most are small in scale, offering modest statistical power. Additionally, they tend to be poorly characterised for socioeconomic position. As a moderate correlate of IQ,[1] indicators of socioeconomic position can be considered as possible confounders or mediators in the IQ–risk factor association depending on the period in time to which they refer relative to this psychological characteristic.[2] For other outcomes, such as diabetes, we are unaware of any published studies of their association with childhood IQ.

Data from the Aberdeen Children of the 1950s study affords us the opportunity to address these issues of data paucity and methodological shortcomings. In this cohort, an order of magnitude larger in size than most others, IQ was assessed at 7, 9 and 11 years of age and study participants reported risk factors in mid-life.[35] Although, as indicated, the primary motivation for examining the link between IQ and risk factors for premature mortality is to explore potential pathways linking IQ with mortality, many of the risk factors studied—heavy drinking, hypertension, diabetes, obesity—are important outcomes in their own right.

METHODS

Study participants

The Aberdeen Children of the 1950s study takes as its subjects 12 150 children born in Aberdeen, Scotland, between 1950 and

Abbreviation: AMND, Aberdeen Maternity and Neonatal Databank

1956 who took part in a school-based survey beginning in 1962.[35–37] At that time, comprehensive information was also abstracted from the Aberdeen Maternity and Neonatal Databank (AMND) about the course of their mother's pregnancy and the children's physical characteristics at birth.[35] Using the National Health Service Central Register, over 98% (n = 12 015) of the cohort were traced.[35] Between 2000 and 2003 we sent a questionnaire containing health-related enquiries to 11 283 surviving study participants, aged between approximately 44 and 52 years. In total, 7183 (63.7%) men and women responded.

Assessment of childhood IQ

During the period in which the study was established in the early 1960s, the educational authorities in Scotland routinely measured IQ as a means of determining the secondary school destination of each child (junior or senior secondary). Tests were administered to school children at 7, 9 and 11 years of age, and these scores were extracted from school records at the time of the schools-based survey.[35] A priori, we elected to assess the predictive value of test results at age 11 because, of the three measures of IQ, this provides the most reliable indication of ability in adult life.[38] IQ scores at 11 years were based on two tests of verbal reasoning (the Moray House verbal reasoning tests I and II).[35] Tests in this series correlate strongly with the Stanford Binet test in both boys (r = 0.81) and girls (r = 0.78).[39] In this study, IQ test scores also reveal the frequently replicated associations with early-life socioeconomic conditions[35] and foetal growth.[40] The relationship between the three childhood IQ test scores and educational attainment was also in the expected direction and of the anticipated magnitude (r between 0.52 and 0.61; p<0.001). These tests therefore appear to have a high degree of concurrent and predictive validity. The magnitude of the intercorrelation coefficients between the test scores was, as anticipated, also high (r = 0.71–0.86; p<0.001).

Assessment of adult risk factors

All risk factors were self-reported. Enquiries related to cigarette smoking included current smoking status and, where applicable, age at initiation and age at cessation. Questions concerning heavy alcohol drinking were based on amount (⩾4 alcoholic beverages 2–3 times per month or more in the past year). Respondents reported whether or not a physician had ever informed them if they had diabetes or hypertension. Participants recorded their height and weight, and indicated if the latter measurement was derived from bathroom weighing scales. Given that persons who indicated that they had not used scales reported lower weight than those who reported they had,[41] all analyses using weight were weighing scale-adjusted. As necessary, height and weight was converted to metric units and the body mass index (kg/m^2) was computed. Overweight (⩾25 kg/m^2) and obesity (⩾30.0 kg/m^2) were defined according to World Health Organization criteria.[42] Below average height for the analytical sample (men: <175.8 cm; women: <161.5 cm) denoted reduced stature in this analysis. Height was also analysed as a continuous variable.

Assessments of other characteristics

We used four indicators of socioeconomic position in childhood (number of siblings,[43] housing tenure, car ownership, social class of the father) and four in middle age (occupational social class, car ownership, housing tenure, income). We also used educational attainment as a covariate which we conceptualised as spanning these two time periods. Information on number of siblings (1, 2, 3, ⩾4) was collected during the 1962 reading survey. The social class of the study participants' fathers at their birth was abstracted from the AMND, and classified into six categories according to the schema resembling the 1950 Registrar General's revision[44 45] (I–II, professional/managerial; IIINM, non-manual, skilled non-manual; IIIM, manual, skilled manual; IV, manual, semiskilled; V, unskilled manual; and unemployed). Housing tenure (childhood classification: owned, council rented, privately rented, 'other'; adult classification: owned, rented, rent free/other), car ownership (childhood classification: yes, no; adult classification: none, one, ⩾two), personal income (<10 000 10–<20 000 20–30 000 ⩾£30 000 per annum), educational attainment (six categories from none to postgraduate qualifications) and adult occupational social class (professional, managerial or technical; semiskilled non-manual; semiskilled manual; partially skilled or unskilled) were ascertained from the 2000–3 questionnaire survey. Birth weight was extracted from the AMND and categorised into three groups (<3000, 3000–3500, ⩾3500 g).

Statistical analyses

All analyses were conducted using Stata (V.8.1). With the exception of analyses where smoking cessation was the outcome of interest, a series of multiple logistic regression models were used to assess the relationship between childhood IQ and adult risk factors. These analyses are based on study participants with compete data for IQ at 11 years, covariates and risk factors (n = 5340; 2687 of whom were women). This group therefore represents in analytical sample. Odds ratios and accompanying 95% confidence intervals per one standard deviation (12.97 points) increase in IQ were computed. All odds ratios were adjusted for sex. Further, because this dataset contains some siblings,[46] leading to clustering of certain data (eg, childhood socioeconomic position), we also adjusted for family status in all analyses. Separate adjustment was also made for indicators of socioeconomic position across the life course (for all outcomes), birth weight (for the outcomes of hypertension, diabetes, overweight, obesity and reduced height) and use of weight scales (for the outcomes of overweight and obesity). In our analyses, we conceptualised childhood measures of socioeconomic position and birth weight as potential confounding variables as they referred to the period before or during IQ measurement. Adult indicators of socioeconomic position and education were regarded as potential mediators as they denoted the period after IQ assessment. All covariates were entered as categorical indices.

To estimate the relationship, if any, between IQ and smoking cessation we performed subgroup analyses in study participants who indicated in middle age if they had ever smoked. Hazard ratios and accompanying confidence intervals per one standard deviation increase in IQ were computed using Cox's proportional hazards regression model[47] with age as the time scale. In these analyses, age at smoking uptake denoted entry into the risk set, while age at cessation denoted "failure".

In preliminary analyses, we assessed if sex modified the relationship between IQ and any of the outcome variables. With the exception of smoking cessation (p value for interaction = 0.04) and reduced height (p = 0.002), there was no strong evidence that it did (p⩾0.28). We therefore present sex-specific analyses for the IQ in relation to these two outcomes only.

RESULTS

Table 1 presents the relationship between the measures of IQ at 7, 9 and 11 years and study covariates. Because, as indicated, the inter-relation between each of the IQ scores was high, the pattern of association that each IQ score exhibited with the study covariates was also very similar. For all covariates, the most favourable level was apparent in the higher IQ scoring persons; thus, birth weight was increased and socioeconomic circumstances in early and later life (based on nine indices) more advantageous.

Table 1 Correlation coefficients for the relationship of IQ at 7, 9 and 11 years with social and physical characteristics of study participants

	IQ at 7 years	IQ at 9 years	IQ at 11 years
Birth weight			
r	0.11	0.09	0.09
n	6905	6803	6813
Father's social class in childhood†			
r	−0.31	−0.29	−0.31
n	6905	6803	6813
Family size in childhood†			
r	−0.24	−0.21	−0.24
n	6898	6774	6807
Housing tenure in childhood			
r	0.24	0.23	0.22
n	6873	6774	6783
Car ownership in childhood			
rpb*	0.17	0.15	0.15
n	6860	6760	6768
Educational attainment			
r	0.52	0.56	0.61
n	6812	6711	6721
Income in adulthood			
r	0.29	0.30	0.32
n	6756	6656	6667
Social class in adulthood†			
r	−0.40	−0.43	−0.46
n	6752	6657	6672
Housing tenure in adulthood			
r	0.23	0.22	0.24
n	6895	6793	6803
Car ownership in adulthood			
r	0.21	0.19	0.19
n	6892	6790	6768

*Point biserial correlation coefficient.
†Higher scores on these variables indicates greater socioeconomic adversity.
For all correlation coefficients, $p<0.001$.

Table 2 presents the associations between childhood IQ and adult behavioural risk factors (smoking and heavy drinking). In sex-adjusted analyses, childhood IQ was inversely related to indicators of smoking and alcohol consumption, whereby the lower prevalence of ever smoking, current smoking, and heavy alcohol consumption was evident in the higher IQ-scoring study participants. The IQ–risk factor gradient was strongest for current smoking, where a one SD advantage in IQ was associated with a 31% decrease in prevalence in middle age ($OR_{\text{per SD increase in IQ}}$ (95% CI) 0.69 (0.65 to 0.74)). We examined the effect, if any, of controlling for potential confounding and mediating variables on the relationship between childhood IQ and these risk factors. There was a suggestion of some attenuation of the associations when markers of early socioeconomic disadvantage—father's occupational social class, number of siblings, housing tenure and car ownership—were added to the multivariable model. Controlling for educational attainment by middle age effectively eliminated the relationship of IQ with heavy drinking and ever having smoked, although not current smoking. Separate adjustment for adult markers of socioeconomic position led to less pronounced attenuation. In a fully adjusted analysis there was no evidence of an association between IQ and any of the aforementioned health behaviours.

Having found that sex modified the effect of IQ on smoking cessation, we report on the findings of the sex-specific analyses in 1640 men and 1602 women who indicated that they had ever smoked cigarettes (table 3). Childhood IQ was positively associated with an increased risk of giving up smoking in an unadjusted analysis; an effect that was somewhat stronger for women (1.37; 1.27, 1.47) than men (1.24; 1.16, 1.32). There was little effect of adjusting for indicators of early-life social circumstances, whereas separately adding education and characteristics of socioeconomic disadvantage in adult life to the multivariable model led to a greater degree of attenuation.

Table 4 depicts the results of analyses in which IQ at 11 years of age was related to physiological risk factors for mortality in middle age. In sex-adjusted analyses, both indicators of adiposity—overweight (0.86; 0.81, 0.91) and obesity (0.78; 0.72, 0.83)—were inversely related to IQ such that the lower prevalence of each was seen in higher scoring IQ persons. These effects were somewhat stronger for obesity than overweight. Controlling for birth weight had no effect on these associations. After adjustment for indices of socioeconomic position in pre-adult and later life, there was only minor attenuation in these relationships; however, education weakened the relation markedly. After collective adjustment for all of these characteristics, the relationship of IQ with obesity, but not overweight, was still apparent at conventional levels of statistical significance. IQ was not related to hypertension or diabetes in any of our analyses.

When reduced height was the outcome of interest (table 5), a considerable interaction with sex again led us to present associations with IQ separately in men and women. In keeping with the analyses of smoking cessation, a steeper IQ–height gradient was apparent in women (0.76; 0.70, 0.82) than in men (0.90; 0.84, 0.98). The former relation was generally more robust to statistical adjustments for foetal growth and indicators of socioeconomic circumstances. To estimate the relationship between IQ at 11 years and adult height using the full range of scores, we also computed Pearson correlation coefficients separately in men ($r = 0.12$; $p = 0.001$) and women ($r = 0.15$; $p = 0.001$). The impact of adjusting for potential confounding and mediating variables in these analyses followed the pattern of results observed using the aforementioned logistic regression technique.

Finally, given the strong association between childhood IQ and educational attainment, we computed the IQ–risk factor relationships for all outcomes across six strata of education. Odds ratios using this approach were essentially the same as those when adjustment was made for education (results not shown).

DISCUSSION

The objective of this study was to examine the relationship between childhood IQ and adult risk factors for premature mortality as potential mechanisms underlying the recently reported IQ–mortality gradient. There was an association between IQ and smoking initiation, heavy drinking, obesity, overweight and reduced height, such that higher IQ scores were associated with a lower prevalence. Persons with higher pre-adult IQ scores were also more likely to stop smoking in later life than their lower performing peers. Most of these associations were, however, eliminated after statistical control for markers of socioeconomic position, particularly in adulthood. Unsurprisingly, given its strong relationship with IQ in this dataset and elsewhere, education had the most consistent and strongest attenuating effect.

As indicated, in broad terms, pre-adult indicators of socioeconomic disadvantage can be conceptualised as confounders in this study, whereas adult markers may be considered as mediators; that adjusting for the latter sometimes led to a pronounced reduction in the magnitude of the IQ–risk factor relationship plausibly implicates a pathway through which early-life IQ may exert an influence on adult risk indices.[3] That is, higher

Table 2 Odds ratios (95% CIs) per one SD advantage in childhood IQ in relation to behavioural risk factors for premature mortality in middle-aged men and women

Adjustment	Ever smoked (2688)	Current smoker (1350)	Heavy drinking (2396)
Sex	0.77 (0.73 to 0.81)	0.69 (0.65 to 0.74)	0.89 (0.84 to 0.94)
Childhood socioeconomic position*	0.83 (0.78 to 0.88)	0.75 (0.70 to 0.81)	0.93 (0.87 to 0.98)
Education	1.00 (0.93 to 1.08)	0.91 (0.83 to 0.99)	0.98 (0.91 to 1.05)
Adult socioeconomic position†	0.88 (0.83 to 0.94)	0.85 (0.79 to 0.91)	0.91 (0.86 to 0.97)
Multiple‡	1.07 (0.99 to 1.15)	1.00 (0.92 to 1.09)	1.00 (0.92 to 1.07)

*Adjusted for sex and father's occupational social class, family size at time of survey (1962), housing tenure of childhood home at 12 years of age, car ownership at 12 years of age.
†Adjusted for sex and housing tenure in adulthood, car ownership in adulthood, occupational social class in adulthood, income in adulthood.
‡Adjusted for all the above covariates.
Analyses are based on 5340 subjects.

IQ test scores may lead to educational success, and entry into well-remunerated, high-status employment with a concomitantly high salary. An alternative, but often ignored, explanation is that educational attainment may represent a proxy for IQ, rather than the converse. That is, people with higher IQs stay longer within education, gaining more and higher qualifications.[48 49] In this study, IQ at age 11 was moderately strongly correlated with subsequent educational attainment ($r = 0.61$; $p = 0.001$). A recent longitudinal study of over 70 000 English school children with more detailed information on educational achievement than this study, found a correlation of 0.81 between IQ at 11 years and GCSE results at 16.[50] As such, including education in our statistical models may be regarded as overadjustment.

Comparison with other studies

As indicated, to date, very few studies have examined the relationship between childhood IQ and adult risk factors for mortality. Smoking initiation was unrelated to IQ in one study,[25] whereas two others[51 52] reported an inverse relationship, as we did. One of these did not provide any effect estimates,[52] while in the other[51] the survey sample was based on a group of individuals classified as unwanted pregnancies who were followed into later life, and is therefore of questionable generalisability. To our knowledge, childhood IQ has been related to smoking cessation in only one study.[25] In that, the hazard ratio per one SD increase in IQ (following further calculation) after control for sex and adult social class (hazards ratio (95% CI) 1.25 (1.05 to 1.33))[25] was similar to our own results. It is also the case that further adjustment for other markers of socioeconomic disadvantage in that study led to a non-significant effect,[25] as it did in this analysis.

For another behavioural risk factor, heavy alcohol consumption, we found a negative association with IQ in sex-adjusted analysis (0.89; 0.84 and 0.94); however, there was evidence of marked attenuation when other covariates were considered. We are aware of only one other investigation of the link between early-life IQ and later heavy alcohol drinking.[28] Using a case–cohort design, IQ ascertained in early adult life was related to heavy drinking at two later time points in a group of obese men and a random sample of the population. There was a suggestion of a U-shaped association with IQ, but none of the point estimates attained statistical significance. As indicated, we have also examined the link between self-reported alcohol-induced hangovers in adulthood and earlier IQ scores in this dataset.[29] That childhood IQ was more strongly related to hangovers than reported alcohol consumption in the current analyses may be due to the greater accuracy of recall of the former.

We are aware of several previous studies relating IQ and obesity,[5 30–34] most of which comprise men. These demonstrate discrepant findings. Further, while only two[5 34] have examined the relationship between childhood IQ and adult obesity, only one of these[34] adjusted for potential mediating or confounding factors as we did. The findings of an inverse relationship between IQ and obesity in cross-sectional[31 53] and case–control studies[30–32]—the study designs most commonly used—raise concerns about reverse causality. That is, rather than low IQ predicting obesity, the development of this condition, with its accompanying social stigma, may result in a failure to thrive cognitively.[30 33] Longitudinal studies facilitate an examination of this issue of reverse causality in at least two ways: either by excluding persons with existing obesity at study induction so that new cases of obesity can be studied, or by controlling for early-life obesity status. In taking the latter approach, we adjusted for childhood body mass index (based on internally derived z scores) in a subgroup of study participants with complete data ($n = 5229$). The apparent protective effect of high childhood IQ against adult obesity remained unchanged, supporting the findings of another report.[34]

Of the two health conditions that can also be considered to be risk factors for mortality in this study—hypertension and

Table 3 Hazards ratios (95% CIs) per one SD advantage in childhood IQ in relation to smoking cessation by middle age

Adjustment	Men (836)	Women (725)
Unadjusted	1.24 (1.16 to 1.32)	1.37 (1.27 to 1.47)
Childhood socioeconomic position*	1.19 (1.11 to 1.27)	1.29 (1.19 to 1.40)
Education	1.09 (1.00 to 1.18)	1.15 (1.05 to 1.26)
Adult socioeconomic position†	1.10 (1.02 to 1.18)	1.21 (1.12 to 1.32)
Multiple‡	1.02 (0.94 to 1.11)	1.08 (0.98 to 1.19)

*Adjusted for father's occupational social class, family size at time of survey (1962), housing tenure of childhood home at 12 years of age, car ownership at 12 years of age.
†Adjusted for housing tenure in adulthood, car ownership in adulthood, occupational social class in adulthood, income in adulthood.
‡Adjusted for all the above covariates. Analyses are based on 1640 men and 1602 women.

Table 4 Odds ratios (95% CIs) per one SD advantage in childhood IQ in relation to physiological risk factors for premature mortality in middle-aged men and women

Adjustment	Obese (949)	Overweight (3020)	Hypertension (861)	Diabetes (89)
Sex	0.78 (0.72 to 0.83)	0.86 (0.81 to 0.91)	0.99 (0.92 to 1.07)	0.93 (0.73 to 1.18)
Birth weight	0.77 (0.72 to 0.83)	0.85 (0.81 to 0.90)	1.00 (0.93 to 1.07)	0.95 (0.75 to 1.20)
Childhood socioeconomic position*	0.80 (0.74 to 0.86)	0.89 (0.84 to 0.94)	1.02 (0.94 to 1.10)	0.91 (0.71 to 1.17)
Education	0.89 (0.81 to 0.98)	0.94 (0.88 to 1.01)	1.02 (0.93 to 1.12)	1.26 (0.89 to 1.78)
Adult socioeconomic position†	0.81 (0.75 to 0.88)	0.84 (0.79 to 0.90)	0.97 (0.89 to 1.05)	1.00 (0.77 to 1.31)
Multiple‡	0.90 (0.81 to 0.99)	0.93 (0.86 to 1.00)	1.02 (0.93 to 1.13)	1.25 (0.89 to 1.75)

*Adjusted for sex and father's occupational social class, family size at time of survey (1962), housing tenure of childhood home at 12 years of age, car ownership at 12 years of age.
†Adjusted for sex and housing tenure in adulthood, car ownership in adulthood, occupational social class in adulthood, income in adulthood.
‡Adjusted for all the above covariates and use of weighing scales (obesity and overweight only). Analyses are based on 5340 subjects.

diabetes—to our knowledge, only hypertension has been related to IQ scores in other studies.[26 27] Both used data directly on measured blood pressure, as opposed to self-reported hypertension as in this investigation. Childhood IQ scores were lower in middle-age and older-age adults with hypertension than in their disease-free counterparts. In one cohort, the full range of individual blood pressure and IQ scores were weakly inversely correlated.[26] In this study we ascertained hypertension in middle age rather than older age, and there was no evidence of a relationship. We also found no suggestion of an IQ–diabetes relation in this study, the first to examine this association.

Strengths and limitations

This study has some advantages over existing work. Firstly, the analytical sample is an order of magnitude larger in size than most other studies examining the link between IQ and risk factors for mortality in later life, thus providing greater statistical power. Secondly, by reporting on the relationship of IQ with a range of risk factors we have been able to examine the specificity of association rather than links with a single outcome. Thirdly, this cohort is particularly well characterised for socioeconomic position through to middle age, so allowing us to examine any independent effect of IQ. Finally, while the data are drawn from participants who still largely reside in Aberdeen, a city in the north east of Scotland, the prevalence of smoking, overweight and obesity is similar to those seen in Scotland-wide surveys.[41] This suggests that our findings have a reasonable degree of national generalisability.

However, this study is not without its limitations. Firstly, the longitudinal nature of the Aberdeen study has inevitably led to some attrition raising concerns about selection bias. There are three potential sources of selection bias: survival (11 283 remain from 12 150), non-response to the questionnaire mailing (7183 remain) and then missing data on questionnaire respondents (5340 remain). Two reports from the Aberdeen study have discussed the issue of selection bias by describing the differences in the early-life characteristics of these groups.[35 54] While there was essentially no difference in the childhood characteristics of the persons traced and those not,[35] unsurprisingly, marked discrepancies were found between questionnaire respondents and non-respondents.[54] The latter were essentially the same as the variation we found for the persons in the analytical sample versus the rest of the cohort (data not shown). Thus, in comparison to persons excluded from the analyses owing to non-response and missing data combined, individuals in the analytical sample were more likely to be female, have parents who were married at their birth, have a non-manual social class of origin, have a higher birth weight, have fewer siblings and be taller in childhood. Men and women in the analytical sample also had markedly higher IQ scores at 7, 9 and 11 years of age. With the variance of IQ scores at 11 years somewhat narrower in the analytical sample (n = 5340; mean = 102.9, SD = 12.97) compared with the full cohort (n = 11 324; mean = 99.4; SD = 13.92), it is likely that the IQ–risk factor relationships reported in this analysis are underestimates of the true effects. These systematic differences between questionnaire responders and non-responders in this cohort are in keeping with the findings from other studies.[55–57] Further, the questionnaire response in middle-aged members of the original cohort in this study (63%) compares favourably with other long-term

Table 5 Odds ratios (95% CIs) per one SD advantage in childhood IQ in relation to reduced height in middle-aged men and women

Adjustment	Men (1341)	Women (1322)
Unadjusted	0.90 (0.84 to 0.98)	0.76 (0.70 to 0.82)
Birth weight	0.92 (0.85 to 0.99)	0.79 (0.72 to 0.85)
Childhood socioeconomic position*	1.00 (0.92 to 1.08)	0.80 (0.74 to 0.88)
Education	0.99 (0.90 to 1.09)	0.84 (0.75 to 0.93)
Adult socioeconomic position†	0.98 (0.90 to 1.07)	0.80 (0.73 to 0.88)
Multiple‡	1.09 (0.99 to 1.21)	0.92 (0.82 to 1.02)

*Adjusted for father's occupational social class, family size at time of survey (1962), housing tenure of childhood home at 12 years of age, car ownership at 12 years of age.
†Adjusted for housing tenure in adulthood, car ownership in adulthood, occupational social class in adulthood, income in adulthood.
‡Adjusted for all the above covariates. Analyses are based on 2653 men and 2687 women.

What is known about this topic

Recent studies report an association between low scores on tests of childhood IQ and later-life mortality. The extent to which this relation may be generated by relationships between IQ and risk factors for premature mortality has yet to be clearly ascertained.

What this paper adds

In the largest study to date to examine the relationship between IQ and a range of behavioural and physiological risk factors, lower scores on a childhood IQ test were associated with an increased prevalence of some indices in middle age, such as obesity and smoking.

Policy implications

The skills captured by IQ tests, such as verbal comprehension and reasoning, may be important in the successful management of a person's health behaviours and their outcomes.

follow-ups of child cohorts including the 1946[58] and 1958[59] British birth cohorts.

Secondly, by relating childhood IQ to adult risk factors for premature mortality we have attempted to assess their potential mediating role in the apparent association between child IQ and premature mortality. To test such pathways fully, however, a dataset with information on childhood IQ, adult risk factors and later mortality would be required. We are aware of one study which holds such data. In the 1946 British birth cohort, an inverse IQ–mortality relationship was evident in men but not women[8] although the number of deaths was low. Adjusting for adult smoking patterns at age 26 years had little effect on this association among men. One explanation might be that smoking habits at 26 are not indicative of later behaviour which influences disease risk; another is that smoking does not lie on the mechanistic pathway linking early-life IQ with adult mortality risk. Further studies are clearly indicated. Thirdly, it is plausible that unmeasured factors in this study (eg, childhood illness) could have influenced both IQ and some of the outcomes under investigation (eg, raised blood pressure, diabetes). However, early-life illness was not assessed in this study.

In this study, childhood IQ was associated with a range of mid-life physiological and behavioural risk factors for premature mortality, such that a raised prevalence of some risk indicators (ie, smoking, heavy alcohol consumption, obesity, reduced stature) was evident in lower IQ-scoring persons. Most of these relationships were not robust to adjustment for life course indicators of socioeconomic position, particularly education. These associations may at least partially explain the link between low childhood IQ and increased rates of premature mortality in adulthood.

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All components of the study revitalisation have been granted various ethical committee permissions, including those from the Multi-centre Research Ethics Committee for Scotland, the Local Research Ethics Committee for Grampian (the region in which Aberdeen falls), and the London School of Hygiene & Tropical Medicine Research Ethics Committee. Tracing of study members using the General Register Office, Scotland, was approved by the Privacy Advisory Committee.

Contributors: David Batty generated the idea for this manuscript, which was developed by Sally Macintyre and Ian Deary. David Batty analysed the data and wrote the first draft of the manuscript. All coauthors made substantial contributions to subsequent revisions of the manuscript.

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