Original Contribution

Childhood Cognitive Performance and Risk of Mortality: A Prospective Cohort Study of Gifted Individuals

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Recent research suggests that childhood cognitive performance is associated with various health outcomes, but the nature of the relation is not well understood. It is unclear whether the association occurs across the continuum of cognitive performance, and if it is independent of socioeconomic status. Prospective data from the Terman Life Cycle Study were used to evaluate the hypothesis of a monotonic relation between childhood intelligence quotient (IQ) and adult mortality and to determine whether there exists a threshold beyond which the protective effects of IQ are no longer evident. A total of 897 individuals of school age who scored 135 or higher on the Stanford-Binet IQ test were recruited in 1922. Cox proportional hazards regression was used to estimate survival over a 64-year period. A 15-point advantage in childhood IQ was significantly associated with a decreased risk of mortality (hazard ratio \(= 0.68\), 95% confidence interval: 0.49, 0.93) for IQ scores up to 163; beyond that, the risk of death plateaued. Results were similar when the sample was limited to those participants whose fathers had nonmanual occupations. Childhood IQ, even at the upper end of the distribution, is a significant predictor of mortality, independent of childhood social position.

child, gifted; health; intelligence; longitudinal studies; mortality

Abbreviations: CI, confidence interval; HR, hazard ratio; IQ, intelligence quotient; SD, standard deviation.

While it is well accepted that an individual’s cognitive performance predicts a host of important outcomes including schooling, occupation, and income, we have only recently entertained the possibility that these skills may have similar advantages in health. A variety of theories suggest that higher levels of cognitive performance are beneficial for adult health outcomes (1–4), and empirical research has begun to show a pattern consistent with those theories: Cognitive performance, measured by intelligence quotient (IQ) in childhood, appears to be significantly and inversely related to morbidity (5–8) and mortality (5, 9–11) in adulthood.

However, many questions remain. Most notably, is the effect of cognitive performance independent of the effect of childhood social position? While many studies have accounted for childhood socioeconomic status, it is unclear whether the association will persist in a socioeconomically advantaged and homogeneous sample.

Another issue yet to be determined is whether the association between cognitive performance in childhood and mortality holds across the full continuum of IQ scores. Research has demonstrated a linear association between childhood IQ and adult health within the normal range of IQ (12, 13). However, we do not know whether childhood IQ predicts mortality even at the higher end of the IQ distribution, or if there is a threshold beyond which there are diminishing returns for health.

The present study is uniquely suited to address these outstanding issues and tests the hypothesis that childhood IQ is monotonically associated with adult mortality within a sample of high-IQ individuals. We also evaluate whether there is
a threshold beyond which the protective effects of IQ are no longer evident. Finally, we test the hypothesis that this relation will hold in a socioeconomically homogeneous group of individuals.

MATERIALS AND METHODS

Study sample

This study uses data from the Terman Life Cycle Study of Children with High Ability, a 64-year prospective study that has followed gifted children every 5–10 years since 1922 (14).

A total of 1,470 children with an IQ of 135 or higher and attending public schools in California were selected for inclusion (14). As several different IQ tests were utilized, this study considered only the 1,026 individuals whose IQ score was obtained through the Stanford-Binet IQ test to ensure that all subjects have an equivalent measure of IQ. The children were, on average, 11 years of age when they joined the study and almost exclusively White (15). The history, methodology, and major findings of this study have been discussed extensively in the literature (14, 15).

The analytical sample was restricted to those who were of school age in 1921–1922, who were known to have survived to age 18 years, and whose date of death was known. The final sample consisted of 862 gifted individuals between the ages of 6 and 18 years (table 1).

To consider whether the association between IQ and mortality is independent of childhood social position, we repeated the analyses, limiting the sample to individuals whose fathers were in nonmanual occupations (n = 659).

Cognitive performance

Cognitive performance was measured by the 1916 Stanford-Binet test. The mean IQ score was 151.4 (standard deviation [SD]: 10.7), with a range from 135 to 200. By contrast, IQ scores in the general population have a mean of 100 and a standard deviation of 15.

Years of follow-up

For these analyses, follow-up began at the age of 18 years, and individuals were followed, on average, 48.0 (SD: 13.6) years. The date of death was obtained through notification by either the subject’s family or study personnel during attempts to locate the subject (16). If an individual had not died, he or she was censored on the date of last contact with the study; 293 individuals died at a mean age of 57.1 (SD: 15.3) years, and the remaining 569 were censored at a mean age of 70.5 (SD: 9.9) years.

Analysis

Cox proportional hazards models were used to estimate the relative risk of mortality by use of the SAS system (17). Ties were handled using the exact method (18), although the number of tied events was small. All models controlled for sex, child health status, and father’s occupation (represented by census groups from I [professional] to VI [semiskilled]).

To assess whether there was a threshold beyond which there were diminishing returns on health, a squared IQ term was added to the model. In this model, obtaining the correct estimation of the hazard ratio for a c point change in IQ requires utilizing information from both IQ and the square of IQ simultaneously: hazard ratio(IQ + c, IQ) = exp[b1c + b2(2IQc + c2)], where b1 and b2 are the parameter estimates of IQ and IQ squared (19, p. 136).

RESULTS

Childhood IQ and mortality

Of individuals in the lowest IQ tertile (IQ: 135–144), 36.8 percent died, followed by 33.6 percent in the middle tertile (IQ: 145–152) and 32.2 percent in the highest tertile (IQ: 153–200). A plot of survival curves for the three categories of IQ suggests that a higher level of cognitive performance in childhood is protective against mortality (figure 1). Individuals in the bottom tertile of the IQ distribution were at significantly increased risk for mortality over the 64-year

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Excluded (%)</th>
<th>Analytical sample (%)</th>
<th>Test of no association (χ²)</th>
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<tr>
<td>Death</td>
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<td>34.0</td>
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<tr>
<td>Female</td>
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<td>Father’s occupation†</td>
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<tr>
<td>Nonmanual</td>
<td>23.2</td>
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<td>Skilled manual</td>
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<td>Farmer</td>
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<tr>
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</tr>
<tr>
<td>Unskilled</td>
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<tr>
<td>Childhood intelligence quotient</td>
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<td></td>
<td>3.0</td>
</tr>
<tr>
<td>135–144</td>
<td>36.6</td>
<td>29.9</td>
<td></td>
</tr>
<tr>
<td>145–152</td>
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<tr>
<td>Excellent/good</td>
<td>88.3</td>
<td>85.0</td>
<td></td>
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<tr>
<td>Fair/poor/very poor</td>
<td>11.7</td>
<td>15.0</td>
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</table>

* p < 0.05.
† Eighty-six individuals did not report their father’s occupation.
study period compared with those in the highest tertile (hazard ratio (HR) = 1.46, 95 percent confidence interval (CI): 1.09, 1.95).

Although results from the categorical analysis suggest a dose-response relation, we examined this relation in more detail, treating IQ as a continuous variable. A one-standard deviation increase in IQ was associated with an 11 percent decreased risk of mortality (HR = 0.89, 95 percent CI: 0.74, 1.07). However, when a squared IQ term was included to evaluate whether there is a threshold beyond which there are diminishing returns on health, both IQ and its squared term were significant, suggesting a significant, but nonlinear, relation between IQ and mortality (table 2). The hazard of death decreases as IQ increases up to a score of 163, after which the risk of death plateaus (analyses not shown). Based on this model (illustrated in table 2), a 15-point increase in childhood IQ, from 135 to 150, is associated with a 44 percent decreased risk of mortality. Among individuals with an IQ of 163 or lower, there is a 32 percent reduced risk of mortality for every one-standard deviation increase in IQ score (HR = 0.68, 95 percent CI: 0.49, 0.93). Within the highest tertile, those with an IQ score greater than 163 (n = 117) had a slightly higher, but nonsignificant, risk of mortality compared with those with an IQ score between 152 and 163 (n = 222) (HR = 1.18, 95 percent CI: 0.76, 1.80).

Limiting the sample to individuals whose fathers were in nonmanual occupations did not change the results (table 2). Although this study cannot evaluate the relative importance of childhood IQ compared with socioeconomic status in predicting mortality, it does suggest that IQ predicts mortality independently of childhood social position.

**DISCUSSION**

Our findings suggest that cognitive performance in childhood, measured by IQ, continues to demonstrate a protective association with mortality even at the higher end of the IQ distribution. This study illustrates that a higher IQ score continues to confer additional health benefits from two to four standard deviations above the mean IQ score of the general population. Equally important is that this association exists independently of childhood socioeconomic status, as findings held when the sample was limited to subjects whose fathers had nonmanual professions. That the association between IQ and mortality did not emerge until follow-up had reached about 30 years (figure 1) is likely due to the initial young age of the sample.

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**TABLE 2. Results of Cox proportional hazards regression, predicting mortality among participants who were originally from California and who were followed from 1921 to 1986**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Full analytical sample (n = 776)</th>
<th>Individuals with fathers in nonmanual occupations (n = 659)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hazard ratio 95% confidence interval</td>
<td>Hazard ratio 95% confidence interval</td>
</tr>
<tr>
<td>IQ</td>
<td>0.73†,§</td>
<td>0.73†</td>
</tr>
<tr>
<td>IQ squared</td>
<td>1.001†,§</td>
<td>1.001†</td>
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<tr>
<td>Female</td>
<td>0.62†</td>
<td>0.67†</td>
</tr>
<tr>
<td>Poor health in childhood</td>
<td>1.07</td>
<td>1.03</td>
</tr>
<tr>
<td>Father’s occupation</td>
<td>0.99</td>
<td>0.90</td>
</tr>
</tbody>
</table>

* IQ, intelligence quotient.
† Corresponds to a one-point advantage in childhood IQ.
‡ p < 0.01.
§ The following example illustrates the calculation of risk associated with a one-standard deviation difference in IQ (150 vs. 135) for an individual in this sample. Hazard ratio = \(\exp[-0.31686(15) + 0.009743(2 \times 15^2 + 15^2)] = 0.555\). Therefore, a 15-point increase in childhood IQ, from 135 to 150, is associated with about a 44 percent decreased risk of mortality.
¶ Eighty-six individuals did not report their father’s occupation.
A strength of this study is that the population is homogeneous in terms of race and socioeconomic status, reducing concern that there may be a related, but unmeasured, covariate that may confound this association.

The homogeneity of the sample, however, poses a limitation as well. Because the study sample was almost exclusively White and limited to individuals with a high childhood socioeconomic status, the study findings may not be generalizable to non-White populations and individuals in lower social positions in childhood.

This study adds to the evidence that childhood cognitive performance has long-lasting effects on health. While little is known as to why that might be, several pathways have been hypothesized. In adulthood, individuals with high IQ may take part in healthier behaviors because they have a better understanding of long-term consequences (20), or they may be better able to navigate and interact with the healthcare system. Furthermore, these individuals may be more likely to have a higher social position in adulthood. Finally, certain cognitive skills may influence health through psychosocial pathways (e.g., sense of control) or by buffering the deleterious effects of stress (21–23).

The growing body of literature suggesting that childhood IQ, regardless of how it is measured, is predictive of morbidity and mortality in adulthood deserves attention. This association is not driven solely by individuals at the lower end of the IQ continuum but is equally strong among gifted individuals. That an increase in childhood IQ continues to confer additional protections against mortality from two to four standard deviations above the mean IQ in the general population is striking. Furthermore, the association appears to be independent of social position in childhood. Further evaluation of mechanisms linking cognitive performance and health may provide new and innovative strategies to reduce morbidity and premature mortality across the life course.

**ACKNOWLEDGMENTS**

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Conflict of interest: none declared.

**REFERENCES**


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