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Childhood Socioeconomic Status Predicts Physical Functioning a Half Century Later

Jack M. Guralnik,[1] Suzanne Butterworth,[2] Michael E. J. Wadsworth,[2] and Diana Kuh[2]

[1]Laboratory of Epidemiology, Demography and Biometry, National Institute on Aging, Bethesda, Maryland.
[2]Medical Research Council National Survey of Health and Development, Royal Free and University College Medical School, London, United Kingdom.

Background. Socioeconomic status (SES) affects health outcomes at all stages of life. Relating childhood socioeconomic environment to midlife functional status provides a life course perspective on childhood factors associated with poor and good health status later in life.

Methods. The British 1946 birth cohort was prospectively evaluated with periodic examinations from birth through age 53 years, when physical performance tests assessing strength, balance, and rising from a chair were administered. Early childhood socioeconomic factors were examined as predictors of low, middle, or high function at midlife. We tested the hypothesis that adulthood behavioral risk factors would explain the childhood SES–midlife physical function associations.

Results. Multiple measures of childhood deprivation were associated with midlife function but in multivariate analyses only father's occupation was associated with low function (relative risk [RR] for manual occupation = 1.6; 95% confidence interval [CI], 1.1–2.3), and only mother's education was associated with high function (RR for lower mother's education = 0.49; 95% CI, 0.34–0.72). Early adulthood behavioral risk factors and middle-age SES and disease status only modestly attenuated the relationship between father's occupation and low function and had no impact on the relationship of mother's education with high function.

Conclusions. The social environment in which a child grows up has a strong association with midlife, objectively measured functional status, which is a reflection of the aging process and chronic diseases accumulated over the life course. Of particular interest is the role of higher maternal education in promoting high midlife functioning.

A large body of research has demonstrated that socioeconomic status (SES), whether measured by income, occupation, or educational attainment, is strongly associated with a wide range of health outcomes. There has been compelling evidence that, beyond an individual's current socioeconomic position, the socioeconomic environment in which a child grows up also has a powerful impact on not only childhood health outcomes but on many health outcomes in adulthood, ranging from specific diseases through all-cause and disease-specific mortality (1,2). The life course approach to epidemiology proposes that early life deprivation may have an independent effect on later life outcomes through a variety of mechanisms (3). Deprivation may (i) cause biological changes that are initiated in childhood and continue to have an effect for many years, (ii) may have its effect because of tracking of low SES into adulthood SES, which then has a direct impact on adult health, or (iii) may be the first hit in a lifelong accumulation of risk.

Health outcomes in older populations are also strongly influenced by lifelong socioeconomic position. Mortality, as well as prevalence and incidence of specific diseases have been examined, but functional outcomes such as disability in activities of daily living have also provided valuable insight into social disparities of the aging process. Disability is an important outcome because it indicates loss of independence and need for help in performing activities necessary in daily life but also serves as a global indicator of overall health status and presence and severity of multiple co-occurring conditions. SES has been shown to be a strong predictor of disability onset in old age (4), and educational attainment is strongly related to active life expectancy (years lived free of disability) in both blacks and whites (5).

Recent research has provided information that allows us to begin to piece together life trajectories that lead to disablement in old age, although no birth cohort has been studied prospectively all the way to old age to fully document this pathway. For example, in a 25-year prospective study (6) it was shown that strength in middle age predicts functional decrements and disability in old age. Combining this result with the finding from a prospective birth cohort study showing that low birth weight is an independent risk factor for poor strength in middle age (7) provides tentative evidence of a link that may span all the way from neonatal factors to old age functional decrements. Using data from this same birth cohort, with 53 years of prospective data, the study presented here evaluates the impact of various aspects of the childhood socioeconomic environment on objective tests of physical function in middle age. The hypotheses of this study are: (i) that childhood socioeconomic indicators will be associated with both low and high function at middle age and (ii) that, given that these relationships are found, they will be explained by behavioral risk factors and overweight in young adulthood and SES attained by middle age. The flow of data collection

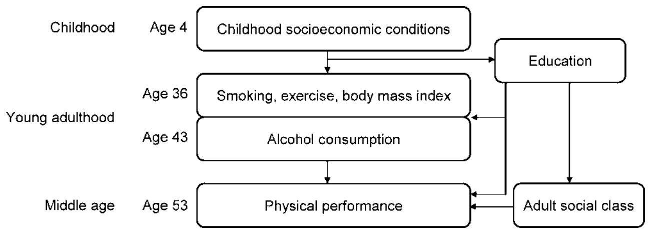

Figure 1. Hypothesized pathways between childhood socioeconomic conditions and midlife physical performance.

over the life course that is used to test these hypotheses is shown in Figure 1.

Methods

Study Population

This study utilizes data collected over 50 years in the Medical Research Council National Survey of Health and Development (NSHD), also known as the 1946 British Birth Cohort Study. The NSHD is a socially stratified sample of births that took place in the first week of March 1946 in England, Scotland, and Wales. At birth, mothers of 2815 boys and 2547 girls were interviewed, and regular follow-up assessments continued through age 53 years. This cohort has been described in detail (8) and remains generally representative of the British population of similar age (9). In 1999, when cohort members were age 53 years, 3035 were successfully contacted, of whom 2988 were interviewed and examined at home and a further 47 provided at least some information on their life circumstances and health status. They represent 56.6% of the original cohort and 70.4% of cohort members still alive and residing in England, Scotland, or Wales. Of the 2988 persons examined, 2767 had complete data on all three performance tests, described below. Ethical approval was obtained from relevant U.K. Multicentre Research Ethics Committees, and all participants gave informed consent.

Childhood SES and Adult Health and Social Characteristics

Information on socioeconomic conditions in childhood was taken from an interview with the mother when the cohort members were age 4. For 84 participants missing these data, data collected at age 11 or 15 were used. Father's occupation was coded using the *Classification of Occupations* to assign occupation to one of six social class categories, which were then dichotomized into manual or nonmanual occupation categories (10). Mother's and father's level of education were classified as primary or secondary or higher, including vocational training. A scale of housing quality at age 4, assessed by the interviewer, assigned 1 point for each of the following items: dwelling in very good repair, dwelling built since 1919, no overcrowding (no more than 1.5 persons per room). Housing quality was classified as good (2–3 points), intermediate (1 point), or worst (0 points). A scale of care of house and child assigned 1 point for each of the following: very clean house, very clean child, at least adequate shoes, at least adequate clothes, mother coped well. Care of house and child was classified as best (5 points), intermediate (3–4 points), or worst (0–3 points).

Behavioral risk factors were obtained from the periodic assessments in which they were evaluated. Smoking status at age 36 was classified as never, ex-smoker, or current smoker. Exercise at age 36 was classified as none, 1–4 times per month, or more than 4 times per month, aggregating responses to a list of 27 sports and recreational activities (11). At age 36, height was measured using a portable stadiometer (CMS, London, U.K.) and weight was measured to the nearest 0.5 kg using the CMS weighing scale, with participants wearing light clothing and no shoes. Body mass index (BMI) was calculated as weight (kg)/height $(m)^2$. Self-reported alcohol intake during the week prior to the home interview was assessed at age 43, and 1 unit was assigned per half pint of beer, one glass of wine, or one measure of spirits.

At age 53, participants were asked about difficulty, due to a long-term health problem, with walking one-quarter mile, walking up and down stairs, gripping or turning lids, or holding something heavy (such as a full kettle), according to Office of Population Censuses and Surveys criteria (12). They were asked: (i) if they easily fell or had difficulty keeping balance due to long-term health problems and (ii) how many times they fell in the past 12 months. Educational status of participants, defined as highest educational qualifications obtained, was classified as no qualifications, qualifications less than a university degree, or university degree or greater. Own social class at age 53 was classified as manual or nonmanual according to occupation. If data at age 53 were missing, information was sought from interviews at age 43, then 36, then 26. Disease status at age 53 was based on self-report of cardiovascular disease (angina, heart attack, stroke, or intermittent claudication), cancer, diabetes, respiratory problems, neurological disease, and musculoskeletal symptoms, described in more detail elsewhere (13).

Physical Performance at Age 53

A team of 82 nurses was trained to perform the physical assessments in participants' homes in a standardized manner according to written protocols (13). Physical performance was evaluated utilizing measures of grip strength, balance, and time to rise from a chair 10 times. Grip strength was measured isometrically using an electronic handgrip dynamometer (14). Nurses strongly encouraged participants to squeeze the dynamometer as hard as possible. Two measurements were taken with each hand, and the highest value was used for these analyses. Intra-subject variability for persons new to such measurements has been shown to be $\pm 9\%$ (15). Balance standing on one leg was assessed using a stopwatch for up to 30 seconds, first with the eyes open and then with the eyes closed (16,17). After an explanation and demonstration by the nurse, one practice attempt was allowed. On a count of three, the participant folded the arms across the chest and bent the knee to raise the preferred foot a few inches off the ground behind the leg. As most participants completed the stand with eyes open, data used here are from the eyes closed test. Chair rise time was

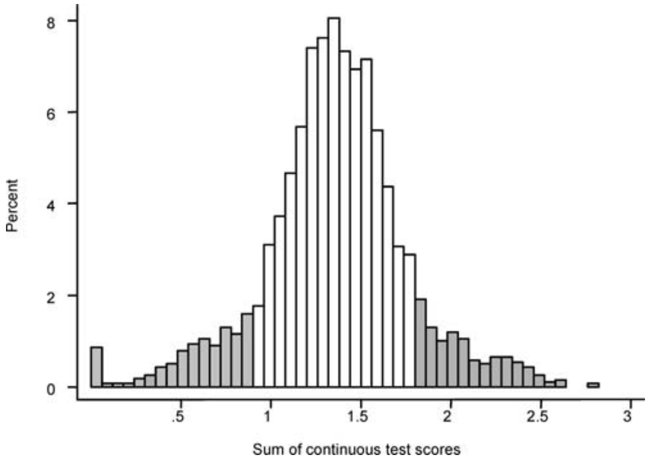

Figure 2. Distribution of the aggregate performance scale, a summed scale of scores on grip strength, one-legged stand with eyes closed, and time to rise from a chair 10 times. Lowest and highest 10% of scores are shaded.

evaluated by using a stopwatch to measure the time it took to rise from a chair to a standing position with straight back and legs and then sit down again 10 complete times. An armless straight-backed chair with a horizontal flat seat was used, and participants were instructed to keep their arms folded across the chest for the full test.

Those participants interviewed who did not have complete performance data were no different from those with complete data in terms of gender ($p = .54$), father's occupation ($p = .74$), and own occupational status ($p = .20$). Among 2767 cohort members with full data on performance, 337 were missing data on father's occupation and/or mother's education. These persons were no different from those without missing data in terms of gender ($p = .63$) and percentage with high and low function ($p = .17$).

Statistical Analyses

Outcomes from each of the three performance tests were rescaled to a 0–1 scale. Grip strength was adjusted for body size by dividing strength in kg by height in cm. The rescaling was done separately for men and women. Adjusted grip strength was divided by the sex-specific 99th percentile value of adjusted grip strength (0.4346 kg/cm for men and 0.2838 kg/cm for women), with persons having values greater than these being assigned these values and persons unable to do the test assigned a 0. Balance was rescaled by dividing the total time the stand with eyes closed was held by 30 seconds, the maximum possible time. Persons unable to hold the position at all were assigned a 0. Rescaled chair rise time was calculated using the equation $1 - (\text{time}/48.0\ \text{s})$, where 48.0 was the 99th percentile of time. Persons unable to rise from a chair 10 times and those persons taking longer than 48.0 seconds were assigned a time of 48.0 seconds. The three rescaled performance scores were summed to create an aggregate physical performance score. The distribution of this score is shown in Figure 2. To evaluate functional outcomes that are potentially meaningful in this middle-aged cohort, we examined associations of childhood and midlife variables with the lowest and highest functioning subsets of the population, defined as the lowest and highest 10% on the distribution shown in Figure 2.

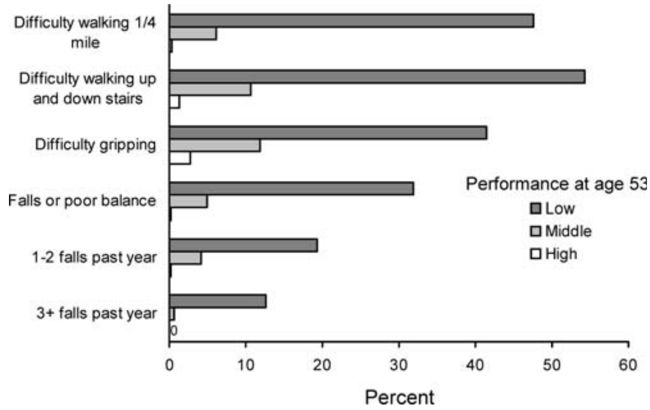

Figure 3. Self-report of disability and falls in persons with poor, middle, and high performance. Weighted to adjust for sampling.

The relationships of low, middle, and high function with self-reported disability and falls were assessed using chi-squared tests. Logistic analyses were used to estimate sex- and sampling weight-adjusted rates of low and high function for categories of social class, BMI, and behavioral risk factors and to test the differences between these categories. Chi-squared tests were used to assess the relationship of childhood socioeconomic indicators and adult BMI and behavioral risk factors. Multivariate polychotomous logistic analysis was used to test the association of childhood SES and adult BMI, behavioral risk factors, education, and occupation with low, middle, and high function at age 53. Indicator variables were used to evaluate specific categories of the behavioral risk factors, and a separate indicator was used to denote missing data for smoking status, exercise, BMI, and alcohol intake. Interaction terms and stratification were used to assess the relationship of father's occupation with performance at age 53 according to mother's education. All analyses adjusted p values and confidence intervals (CIs) for the initial sampling procedure using STATA software, version 7.0 (18).

Results

The two functional states studied here, lowest and highest 10% of function, represent the two tails of the nearly normal distribution of function shown in Figure 2. Evidence that these two tails represent true extremes of functioning is shown in Figure 3. Persons classified as low functioning reported high rates of difficulty walking one-quarter mile, walking up and down stairs, and gripping; they also reported poor balance and were much more likely to have fallen in the past year compared to the remainder of the cohort. In contrast, the high functioning subset of the cohort had rates of reported difficulty and falls that were nearly zero.

Table 1 shows the distribution and relationship to poor and high function of childhood and adulthood characteristics of the cohort. Men were less likely to be poor functioning and more likely to be high functioning than were

Table 1. Distribution of Childhood, Midlife, and Adult Social Class Characteristics of Total Cohort and Proportion With Low and High Function at Age 53 for These Characteristics

Characteristics	Total (%)	Low Function (%)	High Function (%)
Total population	100.0	10.0	10.0
Gender			
Male	49.0	8.8	13.4
Female	51.0	12.3*	5.8*
Childhood factors			
Father's occupation at age 4			
Nonmanual	42.6	6.8	11.4
Manual	57.4	12.2*	7.8*
Father's education			
Secondary	30.3	7.4	15.3
Primary only	69.7	11.7*	7.2*
Mother's education			
Secondary	23.5	6.7	15.0
Primary only	76.5	11.4*	7.5*
Housing quality at age 4			
Best (+)	54.3	8.8	9.4
Intermediate	25.3	11.6	8.5
Worst	20.4	13.5*	7.6
Care of house and child at age 4			
Best (+)	43.5	9.1	10.2
Intermediate	26.4	11.0	9.3
Worst	30.1	12.1	7.2
Midlife factors			
Smoking at age 36			
No (+)	31.1	9.3	9.8
Quit	37.8	9.1	9.4
Current	31.2	13.2*	7.4*
Exercise at age 36			
None (+)	36.3	13.6	6.0
1–4 times/mo	25.4	8.7*	7.4
>4 times/mo	38.3	7.3*	12.0*
BMI at age 36, kg/m^2			
<20	10.2	11.9	10.3
20–24.99 (+)	58.8	8.0	9.9
25–29.99	25.8	11.9*	6.0*
≥30	5.2	25.9*	6.2
Alcohol intake at age 43, units/wk			
0	21.9	14.2*	7.2
1–13 (+)	58.0	9.1	10.1
14–20	9.9	8.9	8.2
≥21	10.1	5.5	7.8
Participant social class			
Occupation, age 53			
Nonmanual	66.3	7.8	10.7
Manual	33.7	13.6*	5.9*
Education (qualifications)			
None (+)	36.2	14.9	6.1
Some qualifications	53.7	7.6*	10.0*
Degree or higher	10.1	3.8*	16.1*

Notes: Percentages are adjusted for sampling weights.

*$p < .05$ comparing to percentage with low or high function for reference category; for two-level variables, reference category is listed first; for multilevel variables, reference category is indicated by (+); all statistical tests were adjusted for sex and sampling weights.

BMI = body mass index.

women. Among childhood factors, father's nonmanual occupation and both parents' secondary education were significantly related to lower rates of low function and higher rates of high function at age 53. Housing quality and care of child and house were associated with function at age 53 in the expected direction but the gradient was of lower magnitude than that observed for occupation and education. Educational status, midlife BMI, and behavioral risk factors (smoking, exercise, and alcohol consumption), and social class at age 53 were associated with function at age 53 in the expected directions, except that the highest category of alcohol intake would be expected to have a higher rate of low function.

Using multivariate polychotomous logistic regression models adjusted for sex and father's occupation, we evaluated childhood factors listed in Table 1 individually for their effect on low and high function over and above the effect of father's occupation. Only mother's education had an additional significant effect on function at age 53 (Table 2, Model 1). Children whose father's occupation was manual had a 60% increase in risk of having low function at age 53. In contrast, father's occupation did not predict high function, but mother's education was a significant predictor of this outcome; study participants with a mother with a primary education were only half as likely to be in the high function group at follow-up compared to children of mothers with at least a secondary education. Figure 4 demonstrates the association with functional outcomes of four groups, defined by father's occupation and mother's education. Father's manual occupation is strongly associated with low function in the group with mothers with primary education. However, there is a buffering of the impact of father's manual occupation on low function among participants with more highly educated mothers, with nearly identical rates of low function in those with manual and nonmanual occupation fathers. In analyses stratified by mother's education, father's occupation was a significant predictor of low function in the primary education subgroup (relative risk [RR] 1.77; 95% CI, 1.18–2.63) but had no relationship with low function in the secondary education subgroup (RR 1.14; 95% CI, 0.46–2.84). However, a formal test of the interaction of father's occupation and mother's education, evaluated by adding this term to Model 1, was not significant ($p = .37$ for low function outcome, 0.67 for high function outcome). Figure 4 also shows the strong effect of mother's education on the high function outcome. In both primary and secondary education subgroups, those participants with a father in a nonmanual occupation did slightly better than those with a father in a manual occupation. However, the magnitude of the effect of mother's education on high function was much larger than that of the father's occupation.

Table 2, Model 2 demonstrates that, even after adjustment for cohort member's own social class at age 53, father's occupation continued to be a significant predictor of low function and mother's education continued to be a significant predictor of high function. Childhood social class was strongly associated with the educational attainment of the study participants themselves ($p < .001$). Among those whose father's occupation was manual, 45.2% attained

Table 2. Relative Risk (95% Confidence Interval) for Poor and High Function at Age 53 According to Childhood Social Factors, Current Social Class, and Adulthood Body Mass Index and Behavioral Risk Factors, Adjusted for Sex and Sampling Weights

	Model 1 (N = 2430)		Model 2 (N = 2412)		Model 3 (N = 2430)	
Characteristics	Low Function	High Function	Low Function	High Function	Low Function	High Function
Father's occupation (manual vs nonmanual)	1.61 (1.14–2.29)	0.84 (0.60–1.19)	1.58 (1.08–2.29)	0.91 (0.64–1.29)	1.38 (0.96–1.98)	0.90 (0.63–1.28)
Mother's education (primary vs secondary)	1.34 (0.83–2.15)	0.49 (0.34–0.72)	1.17 (0.71–1.91)	0.53 (0.36–0.78)	1.35 (0.83–2.18)	0.52 (0.36–0.76)
Current social class (manual vs nonmanual)			1.61 (1.15–2.26)	0.66 (0.45–0.97)		
Smoking status at age 36 (vs no)						
Quit					1.13 (0.74–1.71)	0.93 (0.63–1.38)
Current					1.54 (1.00–2.36)	0.64 (0.39–1.04)
Exercise at age 36 (vs none)						
1–4 times/mo					0.74 (0.48–1.15)	1.17 (0.70–1.96)
>4 times/mo					0.67 (0.45–1.02)	1.70 (1.10–2.64)
Body mass index at age 36 (vs 20–24.99)						
<20					1.22 (0.69–2.18)	0.98 (0.55–1.74)
25–29.99					1.34 (0.81–1.98)	0.64 (0.43–0.97)
≥30					3.90 (2.28–6.70)	0.88 (0.37–2.10)
Alcohol intake age 43 (vs 1–13 units/wk)						
0					1.37 (0.92–2.06)	0.80 (0.48–1.32)
14–20					0.90 (0.48–1.69)	0.89 (0.51–1.56)
≥21					0.44 (0.21–0.92)	0.85 (0.49–1.47)

some qualifications or a university degree, whereas this percentage was 82.1% for participants whose father's occupation was nonmanual. However, when participant's own education was included in Model 1, there was only modest attenuation of the relationships (RR for low function for manual vs nonmanual father 1.46; 95% CI, 1.00–2.13; RR for high function for primary vs secondary education mother 0.57; 95% CI, 0.38–0.85).

Table 3 demonstrates that adulthood behavioral risk factors and BMI were also associated with father's occupation and mother's education. Their relationships with both childhood socioeconomic variables and functional outcomes at age 53 thus make these young adulthood risk factors potential mediators of the relationship between childhood SES and function at age 53 (Figure 1). Including adult behavioral risk factors and BMI in the model (Table 2,

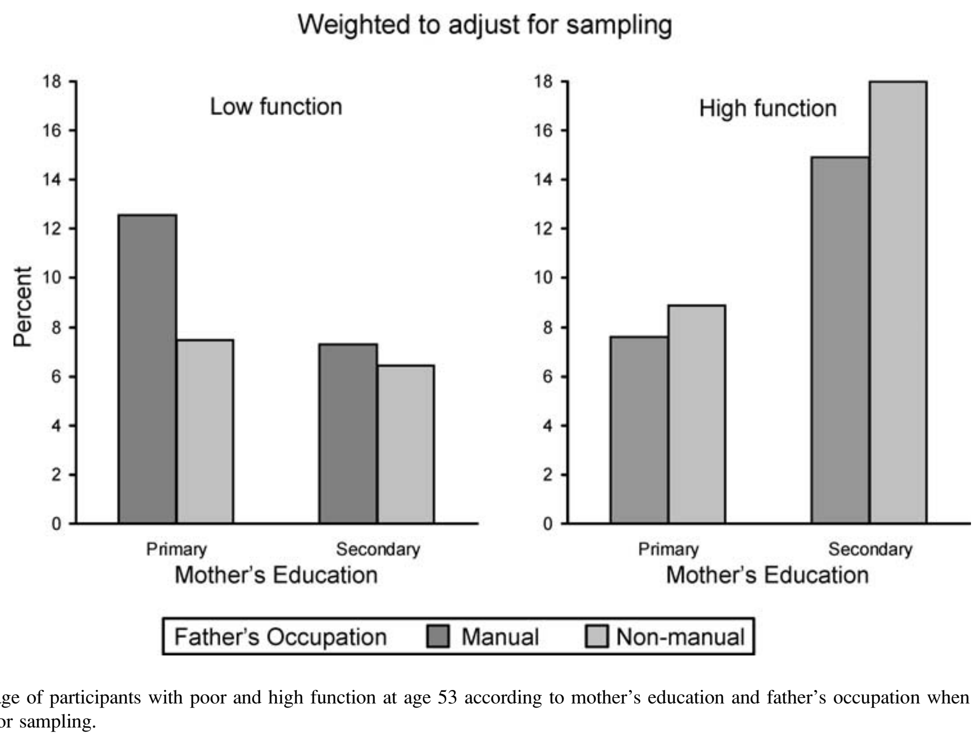

Figure 4. Percentage of participants with poor and high function at age 53 according to mother's education and father's occupation when participant was age 4. Weighted to adjust for sampling.

Table 3. Distribution of Adulthood Factors According to Father's Occupation and Mother's Education

	Father's Occupation		Mother's Education	
Adulthood Factors	Manual	Nonmanual	Primary	Secondary
Smoking at age 36				
No	28.7	33.6*	30.6	27.6*
Quit	35.5	41.0	35.0	43.9
Current	35.8	25.4	34.5	28.6
Exercise at age 36				
None	40.9	29.5*	39.2	32.1*
1–4 times/mo	23.8	27.6	25.3	22.9
>4 times/mo	35.3	42.9	35.6	45.0
Body mass index at age 36, kg/m^2				
<20	8.7	11.0	8.4	13.8*
20–24.99	54.5	64.5	56.0	60.5
25–29.99	31.0	21.2	30.0	21.3
≥30	5.9	3.3	5.6	4.5
Alcohol intake at age 43, units/wk				
0	23.4	18.5*	22.8	17.2
1–13	55.1	62.8	56.3	62.8
14–20	9.9	9.9	10.0	10.1
≥21	11.6	8.9	10.9	9.9

Note: $*p < .05$ comparing distributions in manual versus nonmanual and primary versus secondary groups, adjusted for sampling weights.

Model 3) attenuated the relationship of father's occupation (RR 1.39; 95% CI, 0.97–2.00), but the relationship of mother's education with high function remained unchanged. Finally, disease status at age 53 was evaluated as a potential mediator of the associations of early life social class and parental education with physical performance at age 53. When Models 1 and 3 in Table 2 were additionally adjusted for cardiovascular disease, cancer, diabetes, respiratory problems, neurological disease, and musculoskeletal symptoms at age 53, the RRs for father's occupation and mother's education were virtually unchanged.

Discussion

Using prospectively collected data from the British 1946 Cohort Study, we assessed the hypotheses that indicators of early childhood SES would be associated with objectively measured physical performance in middle age and that young adulthood behavioral risk factors and adulthood SES would be mediators of this relationship. The first of these hypotheses was confirmed, with multiple measures of childhood deprivation, including father's occupation, both parents' education, housing quality, and care of child and house found to be related to later life functional status in the expected directions. However, in models adjusted for father's occupation, only it and mother's education remained significant predictors.

An unexpected finding in this research was the specificity of the relationships, with father's occupation being the best predictor of low function and mother's education the best predictor of high function. Cohort members whose mothers had a secondary education were twice as like as those whose mothers had a primary education to be in the highest decile of physical performance at age 53. Although maternal education was related to father's occupation, the results when they were discordant are particularly interesting. Persons with a father in a manual occupation but a mother with a secondary education had about the same low incidence of low function as all persons with a father in a nonmanual occupation (Figure 4). Having a mother with a primary education led to a substantially lower likelihood of high function, even when the father had a nonmanual occupation. The potent effect of having a mother with a higher educational level has been shown for several early life health indicators, including lower childhood mortality (19,20), and asthma and diabetes (21). What has not been demonstrated, to our knowledge, is that a mother's education has a positive impact on the occurrence of high functioning in her adult child some 50–70 years after that education took place.

The second hypothesis in this work, that we could identify mediators of the relationships between childhood SES and midlife function, was only partially supported. BMI and behavioral risk factors in the 30s and 40s were found to be related to childhood SES and middle-age function, and they modestly attenuated the relationship between father's manual occupation and low function (Table 2). However, although better health behaviors in children of higher educated mothers seem likely mediators, the relationship of mother's secondary education with high function was unchanged after adjustment for adult BMI and behavioral risk factors. Furthermore, although there was tracking from parents' occupation or education to child's SES, adjusting for study participants' current social class or educational status had no effects on the relationships between early childhood factors and middle-age function. Although not specifically addressed, access to medical care is unlikely to play a role as universal health care in Britain was initiated just after this cohort was born. The mechanism whereby childhood socioeconomic environment affects middle-age functional performance therefore remains largely unexplained in these analyses.

It is worth further investigation to elucidate why mother's education, specifically, has such a strong impact on high functioning in middle age. Higher maternal education has been demonstrated to influence healthier eating habits (22), more exercise in childhood (23), and better mental health (24), and even slight improvements in these factors over the full life span could be important in promoting high level functioning. In attempting to go beyond health behaviors and medical care as explanatory factors for the effects of SES, researchers have begun to explore additional variables such as hopelessness, depression, hostility, sense of coherence, and locus of control (25,26). The salutary effects of higher mother's education could potentially be explained by its beneficial effects on factors such as these, or on other factors, such as cognitive function and weight trajectories over the entire life course, which have been shown in this cohort to be associated with midlife functional status (27).

The outcome of interest in this study was a summary of performance on tests of grip strength, balance, and rising from a chair. These performance tests represent somewhat different physiologic domains but are related to each other, and their aggregation was aimed at providing an overall summary of middle-aged physical functioning. The summarization resulted in a normal distribution of scores, and the decision to assess factors related to the lowest and highest 10% was made to tap into extremes of performance that may be more revealing in a middle-aged population that is generally functioning well. Figure 3 demonstrated that people at these extremes report functional abilities in their daily lives very different from those of the large group in the center. Midlife functional decrements are the beginning of a process of functional decline that results in high disability rates at old age, and studying this process when it is just beginning may give a clearer picture about important variables related to these outcomes.

This main strengths of this study are its use of data from the British 1946 birth cohort, a unique resource with multiple rounds of prospectively collected data available from birth to age 53, and the availability of objective measures of function at age 53. Although this is an exceedingly long follow-up, it is not possible to come to conclusions about the impact of childhood factors on old age disability until the cohort is followed even longer to obtain those outcomes. A further limitation is the attrition that is an inherent part of any cohort studied for many years. Recent work has shown that although there has been some dropout, the current sample is generally representative of the nonimmigrant English population today (9). A final limitation is the uncertain generalizability of the study to contemporary children in Britain or in other countries. The cohort began in a unique time in history after World War II. A substantially higher percentage of children at that time had parents who were manual workers and had lower education than in current times.

Despite these limitations, this work provides evidence for one part of a chain of events that links early life factors with health outcomes in old age. Poor physical performance, including the three tests used here, has been associated with risk of progression to frank disability and death within the elderly population (28–32), and strength measured in middle age is predictive of old age functional limitations and disability (6). No prospectively measured data exist across the full life span, but childhood factors found to predict physical performance in middle age would likely have a relationship with old age disability. Socioeconomic environment is demonstrated here to be one of these childhood factors. Even more provocative is the differential effect of father's occupation and mother's education on poor and high function. The richness of the environment in which children grow up appears to have a substantial impact on health at older ages. Financial advantages, related to father's occupation, play a role in this, but richness also results from having a more highly educated mother.

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Address correspondence to Jack M. Guralnik, MD, PhD, National Institute on Aging, 7201 Wisconsin Ave., Room 3C-309, Bethesda, MD 20892. E-mail: jg48s@nih.gov

References

1. Kuh D, Hardy R, Langenberg C, Richards M, Wadsworth ME. Mortality in adults aged 26-54 years related to socioeconomic conditions in childhood and adulthood: post war birth cohort study. *Br Med J*. 2002;325:1076–1090.
2. Galobardes B, Lynch JW, Smith GD. Childhood socioeconomic circumstances and cause-specific mortality in adulthood: systematic review and interpretation. *Epidemiol Rev*. 2004;26:7–21.
3. Kuh D, Ben-Shlomo Y. *A Life Course Approach to Chronic Disease Epidemiology*. New York: Oxford University Press; 2004.
4. Stuck AE, Walthert JM, Nikolaus T, Bula CJ, Hohmann C, Beck JC. Risk factors for functional status decline in community-living elderly people: a systematic literature review. *Soc Sci Med*. 1999;48: 445–469.
5. Guralnik JM, Land KC, Blazer D, Fillenbaum GG, Branch LG. Educational status and active life expectancy in older blacks and whites. *N Engl J Med*. 1993;329:110–116.
6. Rantanen T, Guralnik JM, Foley D, et al. Midlife hand grip strength as a predictor of old age disability. *JAMA*. 1999;281:558–560.
7. Kuh D, Bassey J, Hardy R, Aihie Sayer A, Wadsworth M, Cooper C. Birth weight, childhood size, and muscle strength in adult life: evidence from a birth cohort study. *Am J Epidemiol*. 2002;156: 627–633.
8. Wadsworth ME, Kuh DJ. Childhood influences on adult health: a review of recent work from the British 1946 national birth cohort study, the MRC National Survey of Health and Development. *Paediatr Perinat Epidemiol*. 1997;11:2–20.
9. Wadsworth ME, Butterworth SL, Hardy RJ, et al. The life course prospective design: an example of benefits and problems associated with study longevity. *Soc Sci Med*. 2003;57:2193–2205.
10. Registrar General. *Classification of Occupations*. London, U.K.: HMSO; 1971.
11. Kuh DJ, Cooper C. Physical activity at 36 years: patterns and childhood predictors in a longitudinal study. *J Epidemiol Community Health*. 1992;46:114–119.
12. Martin J, Melzer H, Elliot D. The prevalence of disability among adults. *OPCS Surveys of Disability in Great Britain. Report 1*. Office of Population Censuses and Surveys Social Survey Division. London, U.K.:HMSO; 1988.
13. Kuh D, Bassey EJ, Butterworth S, Hardy R, Wadsworth ME, for the Musculoskeletal Study Team. Grip strength, postural control, and functional leg power in a representative cohort of British men and women: associations with physical activity, health status, and socioeconomic conditions. *J Gerontol Biol Sci Med Sci*. 2005; 60A:224–231.
14. Bassey EJ, Harries UJ. Normal values for handgrip strength in 920 men and women aged over 65 years, and longitudinal changes over 4 years in 620 survivors. *Clin Sci*. 1993;84:331–337.
15. Bassey EJ. Longitudinal changes in selected physical capabilities: muscle strength, flexibility and body size. *Age Ageing*. 1998; 27(Suppl 3):12–16.
16. Rikli R, Busch S. Motor performance of women as a function of age and physical activity level. *J Gerontol*. 1986;41:645–649.
17. Kronhed G, Moller C, Olsson B. The effect of short-term balance training on community-dwelling older adults. *J Aging Phys Act*. 2001; 9:19–31.
18. Stata Corp. Stata Statistical Software: Release 7.0. College Station, TX: Stata Corporation; 1999.
19. Mellington N, Cameron L. Female education and child mortality in Indonesia. *Bull Indones Econ Stud*. 1999;35:115–144.
20. Sastry N. Trends in socioeconomic inequalities in mortality in developing countries: the case of child survival in Sao Paulo, Brazil. *Demography*. 2004;41:443–464.

21. Gissler M, Rahkonen O, Jarvelin MR, Hemminki E. Social class differences in health until the age of seven years among the Finnish 1987 birth cohort. *Soc Sci Med*. 1998;46:1543–1552.
22. Giskes K, Lenthe Fv F, Brug HJ, Mackenbach J. Dietary intakes of adults in the Netherlands by childhood and adulthood socioeconomic position. *Eur J Clin Nutr*. 2004;58:871–880.
23. McVeigh JA, Norris SA, de Wet T. The relationship between socio-economic status and physical activity patterns in South African children. *Acta Paediatr*. 2004;93:982–988.
24. Harper S, Lynch J, Hsu WL, et al. Life course socioeconomic conditions and adult psychosocial functioning. *Int J Epidemiol*. 2002; 31:395–403.
25. Lynch JW, Kaplan GA, Salonen JT. Why do poor people behave poorly? Variation in adult health behaviours and psychosocial characteristics by stages of the socioeconomic lifecourse. *Soc Sci Med*. 1997;44:809–819.
26. Berkman CS, Gurland BJ. The relationship among income, other socioeconomic indicators, and functional level in older persons. *J Aging Health*. 1998;10:81–98.
27. Kuh D, Hardy R, Butterworth S, et al. Developmental origins of midlife performance: evidence from a British birth cohort. *Am J Epidemiol*. In press.
28. Guralnik JM, Simonsick EM, Ferrucci L, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol Biol Sci Med Sci*. 1994;49A: 85–94.
29. Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower extremity function in persons over the age of 70 years as a predictor of subsequent disability. *N Engl J Med*. 1995;332: 556–561.
30. Gill TM, Williams CS, Tinetti ME. Assessing risk for the onset of functional dependence among older adults: the role of physical performance. *J Am Geriatr Soc*. 1995;43:603–609.
31. Rantanen T, Harris T, Leveille SG, et al. Muscle strength and body mass index as long-term predictors of mortality in initially healthy men. *J Gerontol Med Sci*. 2000;55A:M168–M173.
32. Rantanen T. Muscle strength, disability and mortality. *Scand J Med Sci Sports*. 2003;13:3–8.

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