Socioeconomic position and twins’ health: a life-course analysis of 1266 pairs of middle-aged Danish twins

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Background The association between socioeconomic circumstances and health in adulthood could come about through processes that may be divided into factors experienced early in life and those experienced in later adulthood. In order to disentangle the influences on health of the early genetic, prenatal and rearing environmental factors from environmental factors later in life, we compared the health status among male and female twin pairs who lived together during childhood and were discordant or concordant on adult socioeconomic position.

Methods A cross-sectional survey among a random sample of middle-aged Danish twins was conducted in 1998–99. The study population included 1266 like-sex twin pairs [52.5% monozygotic (MZ) and 47.6% dizygotic (DZ)]. Data were obtained on childhood and adult social class and on height, BMI, grip strength, depression symptoms, self-rated health, cognitive function, physical activity, smoking, alcohol and food intake.

Results The expected associations between the individual twins’ adult social class and health measures were observed. Among DZ male twins discordant on adult social class, the higher social class twin was on average significantly taller and had higher cognitive test scores. Among DZ female twins discordant on adult social class, the higher social class female twin was more physically active and had a higher cognitive test score. There were no significant health disparities or behavioural differences between the members of MZ twin pairs discordant on adult social class. For most health outcomes, the variability within twin pairs was related to zygosity (higher for DZ than for MZ) but not to social class.

Conclusion This study suggests that the relationship between adult social class and health outcomes in Denmark is due mainly to selection effects rather than a causal effect of social class exposures on health and behaviour.

Keywords Social class, health status, twin study

The association between socioeconomic circumstances and health in adulthood could come about through processes that may be divided into factors experienced early in life (genetic factors, prenatal environmental exposures and the family environment during childhood) and those experienced later in adult life (family and working environment during adulthood), respectively. Alternatively, the association of adult social class and health could be non-causal, arising because healthy individuals are more likely than non-healthy individuals to achieve high social standing. The latter is often termed a selection effect where individuals whose genotypes and early rearing environments dispose them to good health are more likely to achieve high social status in adulthood than individuals without these early advantages. The study of twins provides a unique opportunity to isolate the effects of adult social class from the genetic and social influences operating early in life. Twins not only share either all [monozygotic (MZ)] or on average half [dizygotic (DZ)] of their genes but, nearly always, also their family environment.
during childhood. Thus, studies of twins discordant for adult social class offer a unique opportunity to determine whether the association of social class with health outcomes is consistent with causal or selection effects.

In order to disentangle the influences on health of the early genetic, prenatal environmental and rearing environmental factors from environmental factors later in life, a recent cross-sectional study compared cardiovascular risk factors among 308 pairs of US female twins who had lived together through childhood and were either discordant or concordant for adult social class. This analysis showed that some cardiovascular risk factors differed more between the members of twin pairs discordant on adult occupational social class than twin pairs concordant for being professionals. Moreover, within the pairs discordant on occupational social class, the working class twin typically fared worse than the professional twin. This finding lends support to the hypothesis that adult health is shaped in part by the unique experiences the two members of twin pair can have when they occupy different social strata in adult life. However, this study from the USA comprised women only, and included too few twin pairs discordant for working class status to allow meaningful parameter estimates.

The aim of the present study was to investigate whether differences in adult socioeconomic position influence the health and behaviour of twins who share genetic constitution and rearing environment. Because the adverse effects of disadvantaged social circumstances appear to cumulate during life, we also explored whether any such influences vary in relation to rearing social class. We use data from a cohort of Danish twins born 1931–52 and compare health status and behaviour among 1266 male and female, MZ and DZ, twin pairs who lived together during childhood and were discordant or concordant on adult social class.

The logic of the co-twin difference method we use is as follows. If the association of adult social class and health outcomes reflects selection effects on early life factors only, then we do not expect health outcome differences in MZ pairs discordant on adult social class because these twins are perfectly concordant on early rearing environmental and genetic factors. Alternatively, health outcome differences in DZ but not MZ pairs discordant for adult social class would suggest that genetic factors underlie selection effects because DZ twins share the same rearing environment but are imperfectly matched on genotype. Finally, an effect of adult social class would be implicated by finding that both MZ and DZ twins discordant for adult social class are also discordant on health and behaviour outcomes.

Methods

Study population

The twin pairs included were members of the study of middle-aged Danish twins (MADTs). The MADT sample was ascertained through the Danish Twin Registry and the Danish Central Person Registry. The sampling framework targeted 240 twins from 120 intact twin pairs (both surviving and living in Denmark) randomly selected from all available twin pairs from each of the 22 consecutive birth years (1931 through 1952). The 120 twin pairs from each birth year consisted of 20 pairs each of monozygotic males (MZM), monozygotic females (MZF), like-sex dizygotic males (DZM) and like-sex dizygotic females (DZF), and 40 pairs of unlike-sex dizygotic (DZOS) pairs. Of the 5280 individual twins in the sampling framework, 90 died prior to the time the survey was undertaken, and 4314 (83%) of the 5190 surviving twins participated in a personal interview and a health examination in late 1998 or early 1999. A total of 546 participants whose twin was a non-respondent were excluded leaving 1884 intact twin pairs. After additional exclusion of 617 DZOS pairs, the study population for the present analyses included 1266 like-sex twin pairs (52.5% MZ and 47.6% DZ).

Data

Interviews were conducted by trained interviewers from the Danish National Institute of Social Research (SFI). The survey, which lasted on average 1½ h, comprised a questionnaire, and tests of cognitive and physical functioning.

Socioeconomic data

Social class was determined using a validated classification developed by the SFI on the basis of self-reported information on type of employment, vocational education and number of subordinates. The participants, their spouses and the major wage earner of the participants’ rearing family were classified into five social classes with I as the highest. Social class I consists of university graduates, self-employed with more than 20 employees and salaried employees with more than 50 subordinates. Social class II consists of self-employed with 6–20 subordinates, salaried employees with 11–50 subordinates, and those having a medium long theoretic education such as school teachers and nurses. Social class III consists of self-employed with a maximum of five employees, and salaried employees with 1–10 subordinates or with specialist work. Social class IV includes salaried employees, and lower level and skilled manual workers. Social class V consists of unskilled manual workers. The initial data analyses showed that the distribution of most of the health outcomes differed only slightly among the three highest classes. These classes were consequently merged to comprise a single high-social-class (H) group. Similarly, because health outcome differences between members of the two lower social classes were minimal, these two groups were combined to form a low-social-class (L) group. Twin pairs were classified with respect to their adult social class as concordant high (HH), discordant low (HL) and discordant (HL) based on whether each twin was in the top three vs bottom two social class groups. For twins who were living with a partner, we also calculated a household social class, which represents the highest social class among spouses. A total of 16% of the twin pairs differed with regard to recall of the rearing social class. These pairs were classified according to the highest recalled class.

Vocational educational attainment was assessed with questions about the highest grade or year of regular schooling and the highest degree earned. For education, the pairs were defined in relation to being concordant or discordant for having a medium or long theoretic education vs lower or no education.
**Data on health and health behaviour**

Height in cm and weight in kg were self-reported and were used to calculate body mass index (weight/height²).

A physical examination consisted of three assessments of grip strength in each hand. We identified the maximum value among the recorded measurements.

The depression score used in the present study was based on the factor analytically derived depression score described by McGue and Christensen. The scale consists of 17 individual symptoms of depression that cover mood and affect (e.g., ‘Are you happy with your life?’; ‘Do you sometimes feel life is not worth living?’) and the somatic sequelae of depression (e.g., ‘Do you find it difficult to concentrate?’; ‘Have you lost pleasure or interest in doing things?’). The total depression scale score used in the present study is both highly internally consistent (α > 0.85) and stable (r > 0.60 over a 2-year interval).

Self-reported health was based on responses to a single item (‘How do you consider your health in general?’), which were dichotomized as excellent/very good vs fair/poor.

Cognitive functioning was assessed using a composite of six brief tests covering four major domains of cognitive functioning (semantic memory, working memory, episodic memory and perceptual speed). The specific tests included in the composite were: (i) fluency (the number of different animals named in a single minute), (ii) forward digit span, (iii) backward digit span, (iv) immediate recall of a 12-item list, (v) delayed recall of the 12-item list and (vi) a speeded digit symbol task in which the respondent was asked to write the digit for each of a sequence of symbols as quickly as possible. The multiple cognitive tests were positively intercorrelated, supporting the formation of a composite score computed by summing the six component scores after standardization.

Physical activity was assessed using a nine-item self-report of the frequency and intensity of walking, running and biking (a common form of transport in Denmark). The resulting scale has an internal consistency reliability of 0.75.

Alcohol consumption was assessed as the number of drinks per day. Results were similar when responses were treated as either continuous or dichotomized data [i.e., drinking 1–21 (males) or 1–14 (females) drinks per week (yes/no)], so we only report those for the dichotomous variable. Further, we included data on current smoking (dichotomized as yes/no) and currently smoking more than 14 g tobacco per day (heavy smoking). Table 1 shows that among twins who were classified in the lower social classes. Similar differences were seen for educational status (data not shown). Table 3 shows that among DZM twins discordant on adult social class, the higher social class twin on average was significantly taller and had higher cognitive test scores.

**Results**

As shown in Table 1, the socioeconomic characteristics were quite similar for male and female twin pairs. At the examination, 30% of the twin pairs were discordant for adult household social class and 23% of male and 15% of female twin pairs were discordant for vocational education. Table 2 shows that most health outcomes differed in relation to the twins’ adult social class among those in younger and older middle-age. In both age groups, the highest BMI, lowest cognitive score test, highest prevalence of poor self-rated health and smoking and lowest prevalence of daily intake of vegetables were seen among twins who were classified in the lower social classes.

**Table 1 Sociodemographic characteristics: middle-aged Danish twins**

<table>
<thead>
<tr>
<th></th>
<th>Male twins (n = 647 pairs)</th>
<th>Female twins (n = 620 pairs)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age in years</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46–54</td>
<td>274</td>
<td>260</td>
</tr>
<tr>
<td>55–69</td>
<td>369</td>
<td>330</td>
</tr>
<tr>
<td><strong>Childhood social class</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>403</td>
<td>418</td>
</tr>
<tr>
<td>Low</td>
<td>230</td>
<td>214</td>
</tr>
<tr>
<td><strong>Adult social class</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both high (HH)</td>
<td>342</td>
<td>309</td>
</tr>
<tr>
<td>Both low (LL)</td>
<td>106</td>
<td>120</td>
</tr>
<tr>
<td><strong>Adult vocational education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both high</td>
<td>416</td>
<td>443</td>
</tr>
<tr>
<td>High/low</td>
<td>146</td>
<td>95</td>
</tr>
<tr>
<td>Both Low</td>
<td>85</td>
<td>71</td>
</tr>
<tr>
<td><strong>Lived at home with co-twin</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;14 years</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>14+ years</td>
<td>625</td>
<td>604</td>
</tr>
<tr>
<td>Monozygotic</td>
<td>335</td>
<td>329</td>
</tr>
<tr>
<td>Dizygotic</td>
<td>312</td>
<td>290</td>
</tr>
</tbody>
</table>

For dichotomous outcomes we calculated the conditional odds ratio (OR) of having the behaviour given that the twin belonged to the low social class among the twins discordant on social class and behaviour. Differences between social classes were tested using t-test, MANOVA and chi-square tests. We also analysed whether twin pair differences depended on zygosity, rearing social class by using multivariate linear and logistic regression. All analyses were done in STATA version 8.
There were, however, no differences regarding the magnitude of health disparities among MZM twins discordant on adult social class. Among DZF twins discordant on adult social class, the higher social class female twin was more physically active, and also seemed to have a higher cognitive test score ($P = 0.07$). There were no such differences for MZF discordant twins. These differences were not related to rearing social class. There were only minor and non-significant differences in self-rated health or behaviour in twins discordant on social class (Table 4). A similar pattern of findings was seen for DZ twins in analyses using data on educational status. With regard to the variability in the continuous health outcomes among the twin pairs in relation to their adult social class, the mean matched absolute difference and within-pair correlations were similar among male and female MZ twins who were either discordant or concordant on social class, and also were similar among DZ male and female twins discordant and concordant on social class (Table 5). Within the social classes, however, for all continuous outcomes, the magnitude of the variability was typically greater and correlation lower for the DZ than the MZ twin pairs, as expected, if the variables in question are genetically influenced.

**Discussion**

In this study among randomly sampled MADTs, we found the expected social class differences in a broad array of health outcomes and behaviours. Individuals from the lowest social
classes had significantly higher BMI, showed lower levels of cognitive function, and were less likely to have a healthy diet and more likely to smoke and rate their health as poor/fair as compared with individuals from the three highest social class groups. Among twin pairs who were discordant for adult social class, however, differences on these same variables were surprisingly small. It was especially striking that there were no significant differences between the two members of MZ twin pairs discordant for adult social class, while the higher social class member of discordant DZM twins was significantly taller and performed better on the cognitive tests than his lower social class member of discordant DZM twin pairs. DZ twins with differing adult social class had significantly higher blood pressure and low-density lipoprotein (LDL) cholesterol and poorer self-rated health than her non-working class twin. DZ twins with differing adult social class suggests that the association is due to selection rather than social class effects.

Our findings stand in contrast to a recent US study. In a similar analysis of US female twins, 32% of twin pairs were found to be discordant for adult occupational social class. This corresponds to the 30% found in the present study. In contrast to our study, however, the US study showed that MZ female twins differing in occupational social class also differed in health outcomes. Specifically, the working class twin had significantly higher blood pressure and lower-density lipoprotein (LDL) cholesterol and poorer self-rated health than her non-working class twin. DZ twins with differing adult social class did not, however, differ in health status and both MZ and

**Table 3** Comparison of health outcomes for twin pairs discordant on adult household occupational social class

<table>
<thead>
<tr>
<th>Continuous health outcomes</th>
<th>Male twin pairs</th>
<th>Female twin pairs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Monozygotic</td>
<td>Dizygotic</td>
</tr>
<tr>
<td></td>
<td>Matched mean difference (95% CI)</td>
<td>Matched mean difference (95% CI)</td>
</tr>
<tr>
<td>Height</td>
<td>0.57 (0.01–1.24)</td>
<td>1.51 (0.10–2.94)</td>
</tr>
<tr>
<td>BMI</td>
<td>−0.18 (0.31–0.35)</td>
<td>0.17 (0.05–1.00)</td>
</tr>
<tr>
<td>Grip strength</td>
<td>0.01 (0.13–0.19)</td>
<td>0.24 (0.35–2.81)</td>
</tr>
<tr>
<td>Depression score</td>
<td>0.11 (0.87–1.10)</td>
<td>−0.38 (1.49–0.73)</td>
</tr>
<tr>
<td>Composite cognitive score</td>
<td>0.11 (0.46–0.69)</td>
<td>1.31 (0.63–2.14)</td>
</tr>
<tr>
<td>Physical activity score</td>
<td>−0.10 (1.70–1.50)</td>
<td>0.36 (1.28–2.81)</td>
</tr>
</tbody>
</table>

Bold values signifies P < 0.05.

**Table 4** Comparison of health behaviour and self-rated health for twin pairs discordant on adult household occupational social class and behaviour

<table>
<thead>
<tr>
<th>Binary health outcomes</th>
<th>Monozygotic male twins</th>
<th>Dizygotic male twins</th>
<th>Monozygotic female twins</th>
<th>Dizygotic female twins</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Risk (OR) of lower class twins having the actual health outcome in discordant pairs (95% CI)</td>
<td>Risk (OR) of lower class twins having the actual health outcome in discordant pairs (95% CI)</td>
<td>Risk (OR) of lower class twins having the actual health outcome in discordant pairs (95% CI)</td>
<td>Risk (OR) of lower class twins having the actual health outcome in discordant pairs (95% CI)</td>
</tr>
<tr>
<td>Safe alcohol consumption</td>
<td>1.78 (0.73–4.56)</td>
<td>0.64 (0.31–1.24)</td>
<td>1.88 (0.79–4.80)</td>
<td>0.73 (0.37–1.44)</td>
</tr>
<tr>
<td>Current smoker</td>
<td>0.35 (0.11–1.00)</td>
<td>1.35 (0.72–2.33)</td>
<td>1.36 (0.58–3.28)</td>
<td>1.38 (0.64–3.07)</td>
</tr>
<tr>
<td>Eat vegetables daily</td>
<td>0.90 (0.32–2.46)</td>
<td>0.84 (0.34–2.04)</td>
<td>0.52 (0.23–1.09)</td>
<td>0.86 (0.45–1.65)</td>
</tr>
<tr>
<td>Eat fruit daily</td>
<td>1.00 (0.49–2.03)</td>
<td>1.00 (0.51–1.95)</td>
<td>0.80 (0.38–1.62)</td>
<td>0.47 (0.20–1.05)</td>
</tr>
<tr>
<td>Poor/fair self-rated health</td>
<td>0.91 (0.37–2.27)</td>
<td>1.69 (0.81–3.65)</td>
<td>1.33 (0.64–2.79)</td>
<td>1.00 (0.46–2.13)</td>
</tr>
<tr>
<td>Continuous health outcomes</td>
<td>Male twin pairs</td>
<td></td>
<td></td>
<td>Female twin pairs</td>
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<tr>
<td></td>
<td>Monozygotic</td>
<td>Dizygotic</td>
<td>Monozygotic</td>
<td>Dizygotic</td>
</tr>
<tr>
<td></td>
<td>Mean matched absolute difference (95% CI)</td>
<td>Mean matched absolute difference (95% CI)</td>
<td>Mean matched absolute difference (95% CI)</td>
<td>Mean matched absolute difference (95% CI)</td>
</tr>
<tr>
<td></td>
<td>Within-pair correlation (95% CI)</td>
<td>Within-pair correlation (95% CI)</td>
<td>Within-pair correlation (95% CI)</td>
<td>Within-pair correlation (95% CI)</td>
</tr>
<tr>
<td>Height</td>
<td>HH 1.10 (0.90–1.31)</td>
<td>0.88 (0.84–0.91)</td>
<td>2.67 (2.21–3.12)</td>
<td>0.37 (0.22–0.51)</td>
</tr>
<tr>
<td></td>
<td>HL 1.28 (1.00–1.56)</td>
<td>0.85 (0.78–0.89)</td>
<td>2.91 (2.32–3.49)</td>
<td>0.41 (0.23–0.56)</td>
</tr>
<tr>
<td></td>
<td>LL 1.07 (0.72–1.43)</td>
<td>0.89 (0.82–0.94)</td>
<td>2.55 (1.74–3.36)</td>
<td>0.51 (0.27–0.69)</td>
</tr>
<tr>
<td>BMI</td>
<td>HH 0.97 (0.81–1.11)</td>
<td>0.67 (0.58–0.74)</td>
<td>1.37 (1.15–1.60)</td>
<td>0.29 (0.14–0.43)</td>
</tr>
<tr>
<td></td>
<td>HL 1.00 (0.77–1.21)</td>
<td>0.69 (0.58–0.78)</td>
<td>1.63 (1.29–1.98)</td>
<td>0.20 (0.04–0.38)</td>
</tr>
<tr>
<td></td>
<td>LL 1.05 (0.70–1.40)</td>
<td>0.64 (0.42–0.77)</td>
<td>1.63 (1.16–2.09)</td>
<td>0.52 (0.29–0.70)</td>
</tr>
<tr>
<td>Grip strength</td>
<td>HH 2.78 (2.35–3.20)</td>
<td>0.66 (0.57–0.73)</td>
<td>3.26 (2.71–3.82)</td>
<td>0.45 (0.32–0.57)</td>
</tr>
<tr>
<td></td>
<td>HL 2.57 (2.00–3.14)</td>
<td>0.67 (0.54–0.77)</td>
<td>3.82 (2.94–4.69)</td>
<td>0.27 (0.07–0.43)</td>
</tr>
<tr>
<td></td>
<td>LL 2.72 (1.95–3.50)</td>
<td>0.60 (0.39–0.75)</td>
<td>3.07 (2.01–4.12)</td>
<td>0.53 (0.29–0.70)</td>
</tr>
<tr>
<td>Depression score</td>
<td>HH 1.17 (0.90–1.44)</td>
<td>0.36 (0.23–0.48)</td>
<td>1.36 (1.01–1.70)</td>
<td>0.20 (0.04–0.35)</td>
</tr>
<tr>
<td></td>
<td>HL 1.50 (1.06–1.93)</td>
<td>0.15 (0.05–0.34)</td>
<td>1.59 (1.08–2.09)</td>
<td>0.15 (0.04–0.34)</td>
</tr>
<tr>
<td></td>
<td>LL 0.69 (0.43–0.95)</td>
<td>0.19 (0.08–0.44)</td>
<td>1.51 (0.88–2.14)</td>
<td>0.05 (−0.22–0.32)</td>
</tr>
<tr>
<td>Composite cognitive score</td>
<td>HH 1.14 (0.96–1.32)</td>
<td>0.59 (0.49–0.68)</td>
<td>1.57 (1.29–1.86)</td>
<td>0.25 (0.10–0.39)</td>
</tr>
<tr>
<td></td>
<td>HL 0.99 (0.66–1.23)</td>
<td>0.56 (0.40–0.68)</td>
<td>1.57 (1.24–1.90)</td>
<td>0.26 (0.07–0.43)</td>
</tr>
<tr>
<td></td>
<td>LL 0.98 (0.67–1.28)</td>
<td>0.43 (0.18–0.62)</td>
<td>1.51 (1.06–1.96)</td>
<td>0.42 (0.17–0.62)</td>
</tr>
<tr>
<td>Physical activity score</td>
<td>HH 2.59 (2.16–3.02)</td>
<td>0.21 (0.07–0.34)</td>
<td>2.67 (2.17–3.16)</td>
<td>0.25 (0.10–0.39)</td>
</tr>
<tr>
<td></td>
<td>HL 2.92 (2.24–3.58)</td>
<td>0.16 (−0.04–0.35)</td>
<td>3.17 (2.48–3.85)</td>
<td>0.18 (−0.02–0.36)</td>
</tr>
<tr>
<td></td>
<td>LL 2.63 (1.82–3.43)</td>
<td>0.21 (−0.06–0.45)</td>
<td>3.03 (2.05–4.01)</td>
<td>0.18 (−0.10–0.43)</td>
</tr>
</tbody>
</table>

HH, both twins high social class; HL, one twin high the other low social class; LL, both twins low social class.
DZ twins discordant on educational level had similar health status. Unfortunately, our study did not include measures of blood pressure and LDL, as in the US study. We did, however, have information on self-rated health, but failed to find the twin pair differences observed in the US study. Moreover, BMI and physical activity were assessed in both studies, but both studies failed to find associations of these measures with adult social class within discordant MZ and DZ twin pairs.

The difference in findings between the US and Danish could be due to differences in the outcome measures. Another factor to be considered when comparing the results from the two studies is whether social class differences are smaller in DK vs the US. Access to health care is universal in Denmark and the poverty rate is low vs the US. Nonetheless, it is worth noting that we observed the expected pattern of social class effects, just not within twin pairs.

Differences between twins and singletons might influence the generalizability of findings from the present study. Twins often live in close contact throughout their life and consequently they might have a more supportive social network and share some of the norms that are associated with a specific social class. Thus, the present study might not enable us to estimate the effect of the full range of social classes. On the other hand, we found social differences in health in this twin population (Table 2) that were comparable to those seen in other general population surveys.

In conclusion, the present study suggests that in Denmark the association of adult social class with health behaviours and outcomes is due primarily to genetic selection effects. That is, according to our data a MZ twin from the lowest social class groups had the same health profile as his or her co-twin from the highest social class group. To investigate the issue further, we suggest more twin studies with comparable health outcomes and larger sample sizes that allow comparisons in the most disparate classes.

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Conflicts of interest: None declared.

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