Comparison of academic performance of twins and singletons in adolescence: follow-up study

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Abstract

Objectives To determine whether twins in recent cohorts show similar academic performance in adolescence to singletons and to test the effect of birth weight on academic performance in twins and singletons.
Design Follow-up study.
Setting Denmark.
Participants All twins (n=3411) and a 5% random sample of singletons (n=7796) born in Denmark during 1986-8.
Main outcome measures Test scores in ninth grade (age 15 or 16), birth weight, gestational age at birth, parents' age, and parents' education.
Results Ninth grade test scores were normally distributed, with almost identical mean and standard deviations for twins and singletons (8.02 *v* 8.02 and 1.05 *v* 1.06) despite the twins weighing on average 908 g (95% confidence interval 886 to 930 g) less than the singletons at birth. Controlling for birth weight, gestational age at birth, age at test, and parents' age and education confirmed the similarity of test scores for twins and singletons (difference 0.04, 95% confidence interval −0.03 to 0.10). A significant, positive association between test score and birth weight was observed in both twins and singletons, but the size of the effect was small: 0.06-0.12 standard deviations for every kilogram increase in birth weight.
Conclusions Although older cohorts of twins have been found to have lower mean IQ scores than singletons, twins in recent Danish cohorts show similar academic performance in adolescence to that of singletons. Birth weight has a minimal effect on academic performance in recent cohorts; for twins this effect is best judged relative to what is a normal birth weight for twins and not for singletons.

Introduction

Children of extremely low birth weight have long term health and educational needs.[1] Even within its normal range, birth weight is positively associated with IQ in children,[2] and large scale studies on twins (who often have low birth weights) from the mid-20th century show that they score four or five IQ points lower than singletons.[3 4] A recent study concluded that twins born in the 1950s continue to be cognitively disadvantaged compared with singletons.[5] None the less, it remains unclear whether an intellectual disadvantage characterises twins in recent birth cohorts, and, if it does exist, whether it is due to a small group of severely affected twins or a shift in the distribution of scores for twins towards lower performance. We compared the performance of twins and singletons and the effect of birth weight on academic performance, using nationwide registers of academic performance in ninth graders born in Denmark during 1986-8.

Methods

We used information from the Danish demographic database, the national hospital discharge register, the medical birth register, the Danish twin register, and the register of compulsory school completion assessments and test scores.[6–9]

Danish students in ninth grade (age 15 or 16) are required to complete a general test of academic achievement, scored on a scale of 0-13 (average performance 8). The tests cover major domains of academic achievement, including Danish and foreign languages, mathematics, hard science, and social science. Test scores are supplemented by teacher ratings, also on a 0-13 point scale. We used the average score for each child and the average of the teacher evaluations completed through ninth grade, and scores for mathematics and Danish separately. Test scores were available for 2002-4 corresponding to the 1986-8 birth cohorts. Our study is based on all twins and a 5% random sample of singletons born in Denmark during 1986-8.

Results

Overall, 3652 twin individuals were live born in Denmark during 1986-8, and a 5% random sample of all liveborn singletons during these three years yielded 8280 additional individuals. The study base included those who survived to 1 January 2003 and had not emigrated. Mortality in this period was significantly higher among twins than among singletons: 2.7% *v* 1.1% (95% confidence interval of difference 1.0% to 2.1%). The excess in twin mortality was limited to the period from birth to 28 days (table). More singletons than twins emigrated (4.8% *v* 3.9%), therefore 93.4% of the twins (n=3411) and 94.2% of the singletons (n=7796) constituted the study base for subsequent analyses.

During their first year, twins spent more days in hospital than singletons: 16.0 *v* 6.6 days (95% confidence interval of difference 8.9 to 9.9 days), whereas only small differences were shown for hospital stays from age 1 to 14 years (table). The percentage of twins and singletons spending more than two months in hospital during their lifetime was the same (0.7%).

The birth weight and gestational age of twins was significantly lower than that of singletons: 2541 g *v* 3449 g, mean difference 908 g (95% confidence interval 886 to 930 g) and 37.0 *v* 39.7 weeks (95% confidence interval of the difference 2.7 to 2.8 weeks). Mothers and fathers of twins were significantly older than those of singletons (29.0 *v* 27.8 and 31.9 *v* 30.8 years). The educational level of parents was similar for twins and singletons.

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Editorial by Deary

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Characteristics of twins and singletons born in Denmark during 1986-8. Values are numbers (percentages) unless stated otherwise

Characteristics	Singletons*	Twins
No of live births	8280	3652
Deaths (days after birth):	90 (1.1)	97 (2.7)
1-28	34 (0.4)	72 (2.0)
≥29†	56 (0.7)	25 (0.7)
Emigrated†	394 (4.8)	144 (3.9)
Study base‡	7796 (94.2)	3411 (93.4)
Mean (SD) median No of days in hospital (age <1 year)	6.6 (9.2) 5	16.0 (18.4) 10
Mean (SD) median No of days in hospital (age 1-14 years)	3.5 (14.1) 0	3.6 (12.5) 1
Hospital stay (days) age 1-14 years:		
None	4064 (52.1)	1673 (49.0)
1-2	1730 (22.2)	827 (24.2)
3-30	1863 (23.9)	841 (24.7)
31-60	86 (1.1)	46 (1.3)
≥61	53 (0.7)	24 (0.7)
Male	4030 (51.7)	1715 (50.3)
Mean (SD) birth weight	3449 (537); n=7771	2541 (547); n=3406
Mean (SD) gestational age	39.7 (1.7); n=7759	37.0 (2.5); n=3406
Mean (SD) maternal age	27.8 (4.8); n=7795	29.0 (4.6); n=3411
Mean (SD) paternal age	30.8 (5.8); n=7738	31.9 (5.7); n=3402
Mean (SD) maternal education§	1.67 (1.72); n=7629	1.72 (1.77); n=3318
Mean (SD) paternal education§	1.58 (1.76); n=7330	1.68 (1.83); n=3233
School performance:		
Test score available	6575 (84.3)	2866 (84.0)
Mean (SD) test score	8.02 (1.06)	8.02 (1.05)
Mean (SD) age at test	16.0 (0.3)	16.0 (0.3)
Teacher score available	6572 (84.3)	2851 (83.6)
Mean (SD) teacher score	8.05 (1.08)	8.09 (1.06)
Mean (SD) age at test	16.0 (0.3)	16.0 (0.3)
Information on all variables	6018 (77.2)	2611 (76.5)

Denominators vary owing to missing values.
*5% random sample of Danish birth cohorts, 1986-8.
†Before 1 January 2003.
‡Rest of table gives percentage of study base.
§0=basic school 8th-10th form; 1=vocational main course; 2=upper secondary education; 3=short cycle higher education; 4=medium cycle higher education; 5=bachelors degree; 6=masters degree and PhD.

Academic performance

Twins and singletons showed almost identical academic performance (figure).

Further multivariate analyses confirmed that twins have similar academic performance to singletons, even after controlling for sex, age at test, birth weight (in grams or centiles), gestational age, and parents' age and education. Overall, the results and pattern of the teachers' evaluations as well as the topic specific tests were similar to that for the overall average score—no differences were found between twins and singletons although twins did slightly better in mathematics (difference 0.13, 95% confidence interval 0.03 to 0.23).

Twins and singletons with missing test scores

The same proportion of twins and singletons (84%) had a test score: a proportion similar to previous Danish studies.[10] Similar proportions of complete test scores for twins and singletons were also found in mathematics, Danish, and English.

Health and social indicators for children with and without test scores (see bmj.com) showed minimal differences that were similar for twins and singletons: individuals without a test score spent more days in hospital and had lower birth weight, younger mothers, and parents of a lower educational level. The percentage with birth weights less than 1500 g was higher among twins without a test score (9.7% *v* 3.5%), suggesting that extremely low birth weight is associated with non-completion of the test. A similar pattern was seen in singletons (1.4% with a test score *v* 0.3%).

Birth weight and single twins

Birth weight had a significant but modest effect on test scores (performance increased 6% of a standard deviation per kilogram increase in birth weight for singletons and 12% for twins). In 1256 pairs of twins with different birth weights (mean difference 309 g), the mean test score was 8.05 for the lighter twin at birth and 8.08 for the heavier twin at birth—a difference of 3% of a standard deviation. In the 102 pairs where the twins had identical birth weight, the mean test score was 7.99.

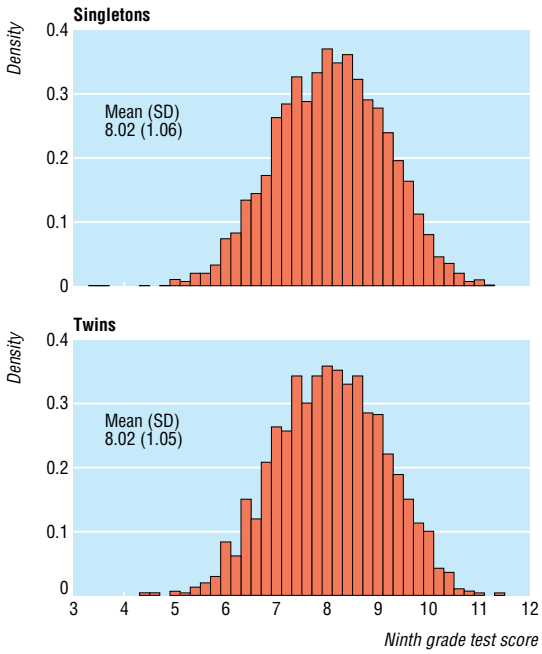
Recent results[1] suggest that children of extremely low birth weight might be especially at risk for several adverse health outcomes and functional limitations. The strongest evidence for an influence of birth weight on later functioning is the over-representation of children of extremely low birth weight in the 15% of the birth cohorts that did not have a test score in the register.

The failure to find twin-singleton differences in light of the observed, albeit modest, effects of birth weight on test scores may seem anomalous. Twins and singletons in the same birthweight centile scored virtually identically, suggesting that relative rather than absolute birth weight is most prognostic (see bmj.com).

The 43 twins with a deceased cotwin scored significantly lower than the 2823 twins with a living cotwin: mean (SD) 7.69 (1.20) *v* 8.03 (1.05); P = 0.04.

Discussion

A large national sample of Danish adolescent twins and singletons showed similar performance in the



Distribution of ninth grade mean test scores for Danish twins (n=2866) and a 5% random sample (n=6575) of Danish singletons, born 1986-8

ninth grade test. Birth weight had a minimal effect on performance except for twins of very low birth weight, who were more likely not to have a test score, suggesting that most twins perform cognitively similar to singletons.

Our findings run counter to the consistent finding of poorer IQ performance among twins in studies of older cohorts, particularly findings from a recently published study.[5] Although the latter study was based on cohorts born in the 1950s, it showed twins continuing to be at a cognitive disadvantage, possibly because of shorter gestation or impaired foetal growth. Our study questions the validity of this generalisation to recent cohorts of twins.

We interpret our findings as indicating that improvements in obstetric and paediatric practices have largely ameliorated the cognitive disadvantage earlier identified in twins,[3–5] despite more twins of extremely low birth weight now surviving their first year. Our findings may differ from those of earlier research because of country specific factors or differences in measurement. Our research is based on measures of academic achievement rather than IQ. A recent review[11] found that the correlation between IQ and standardised achievement tests is high (average 0.70 to 0.74). The correlation between IQ and national achievement tests, such as the test used here, seem almost this high.[12]

The strength of the study is that it is large and register based and that important covariates were available for most participants. The expected associations with covariates were observed in our sample, suggesting data of high quality. The major weakness of the study is that we had no information on why test data were missing for about 15% of the population. Missing data can arise because children are too handicapped to be tested and because some schools do not report test scores. Nonetheless, the equal representation of twins and non-twins in the study (84% had scores identified in both groups) makes bias from this source unlikely.

Record et al[3] showed that the four or five IQ point disadvantage found in twins from cohorts born in the 1950s did not exist among the subgroup of twins who lost their cotwin early in life, suggesting that social competition may be the cause of the twin disadvantage. We found the opposite.

Our study indicates that twins and singletons of extremely low birth weight have lower academic achievement in adolescence than children of average birth weight, and we were able to retrieve reported associations between birth weight and school achievement, although the size of the effect was modest. When we analysed birth weight as centiles separately for twins and singletons, we found no meaningful differences in test scores in any centile stratum.[13] The shift in distribution of birth weight for twins therefore seems to have no effect on cognition in recent twin cohorts. This finding also suggests that the association of birth weight with academic achievement may not be causal, at least within the range of birth weights studied here.

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Ethical approval: This study was approved by the Danish Data Protection Agency (case No 2000-54-0047).

What is already known on this topic

In older cohorts twins have mean IQ scores considerably lower than singletons

Previous studies show a positive association between birth weight and IQ in children

What this study adds

Twins in recent cohorts have school performance in adolescence similar to singletons

Birth weight has a minimal effect on school performance in recent cohorts and for twins this is best judged relative to what is a normal birth weight for twins not singletons

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Endpiece

Complex yet delicate

In order to suck a liquid, the lips serve as a pipe and the tongue as a piston. The trachea is attached to the lungs like a kind of smooth, specially shaped flute which . . . modifies the air and changes the sounds . . . The vessels have their valves or valvules which point in all directions; the bones and muscles have their pulleys and their levers . . . All these machines are simple. . .easy to operate and. . .so delicate that other machines are crude by comparison

Submitted by Amar Bhat, senior house officer, Doncaster Royal Infirmary

Bossuet the Iatromechanic, Bishop of Meaux, c1550. In: Jean-Sournia J-C. *The Illustrated History of Medicine*