We conclude that there is no credible evidence that choosing to terminate an unwanted first pregnancy puts women at higher risk of subsequent depression than does choosing to deliver an unwanted first pregnancy. Delivering a first unwanted pregnancy is, however, associated with lower education and income and larger family size—all risk factors for depression. If the goal is to reduce women's risk for depression, research should focus on how to prevent and ameliorate the effect of unwanted childbearing, particularly for younger women.

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The cognitive cost of being a twin: evidence from comparisons within families in the Aberdeen children of the 1950s cohort study

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Abstract

Objectives To determine whether twins have lower IQ scores in childhood than singletons in the same family and, if so, whether differences in fetal growth explain this deficit.

Design Cohort study.

Setting Scotland.

Participants 9832 singletons and 236 twins born in Aberdeen between 1950 and 1956.

Results At age 7, the mean IQ score of twins was 5.3 points lower (95% confidence interval 1.5 to 9.1) and at age 9, 6.0 points lower (1.7 to 10.2) than that of singletons in the same family. Adjustment for sex, mother's age, and number of older siblings had little effect on these differences. Further adjustment for birth weight and gestational age attenuated the IQ difference between twins and singletons: the difference in mean IQ was 2.6 points (−1.5 to 6.7) at age 7 and 4.1 points (−0.5 to 8.8) at age 9.

Conclusions Twins have substantially lower IQ in childhood than singletons in the same family. This effect cannot be explained by confounding due to socioeconomic, maternal, or other family characteristics, or by recruitment bias. The reduced prenatal growth and shorter gestations of twins may explain an important part of their lower IQ in childhood.

Introduction

Most previous studies report that twins have lower cognitive ability than singletons. In a UK study of children born between 1950 and 1954, twins had a deficit in verbal reasoning scores at age 11 of 4.4 points on average.[1] In a US study of hospital births delivered in 1959-65, twins scored lower in cognitive tests at 8 months, 4 years, and 7 years.[2] In a sample of Australian schoolchildren born in the 1960s, singletons performed better than twins in tests of word knowledge, reading, and numeracy at ages 10 and 14.[3] Among 10 year olds in Stockholm born in 1953, singletons had higher verbal ability and numerical test scores than twins.[4] Recently, a study using the Netherlands twin registry found no evidence for a difference in cognitive ability between singletons and twins in the same family.[5] However, this study did not adjust for potential confounding factors that vary between siblings in the same family, such as maternal age and order among siblings.

We used a within family design to investigate the deficit in cognition between twins and singletons. Instead of using a twin registry we identified families containing twins and singletons from a representative cohort of all people born in Aberdeen, Scotland, and attending primary school there in 1962. We also take our analysis further than others by looking at how far any true twin deficit results from reduced intrauterine growth of twins or shorter gestation.

Methods

Subjects and data

Our study subjects participated in the Aberdeen children of the 1950s study.[6] This comprises 12 150 individuals born in Aberdeen between 1950 and 1956 and who took part in the child development survey in

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Table 1 Estimates of crude and adjusted overall mean differences in IQ between singletons and twins, at ages 7 and 9

	Mean difference in IQ in singletons *v* twins (95% CI)	
Adjustment for:	**At age 7**	**At age 9**
None	6.6 (4.4 to 8.8)	6.9 (4.5 to 9.2)
Sex	6.6 (4.4 to 8.8)	6.9 (4.5 to 9.2)
Maternal age at delivery	7.0 (4.8 to 9.2)	7.2 (4.8 to 9.6)
No of older siblings	6.5 (4.3 to 8.6)	6.3 (4.0 to 8.7)
Father's social class at birth	6.4 (4.3 to 8.5)	6.7 (4.4 to 8.9)
Birth weight (continuous)	3.1 (0.8 to 5.4)	3.8 (1.3 to 6.3)
Gestational age (continuous)	4.7 (2.5 to 6.9)	5.1 (2.7 to 7.5)
Birth weight z score (continuous)	4.9 (2.7 to 7.1)	5.3 (2.9 to 7.7)

Aberdeen primary schools in 1962.[7] A large number of participants (5048) have a sibling in the cohort.

While at primary school, all children were routinely given written cognitive tests within six months of their 7th or 9th birthday. The original survey team in 1962 abstracted information about the test scores from school records; 11 669 took the test at age 7 and 11 376 at age 9. The Moray House picture intelligence test No 1 or 2 was used at age 7. This is a test based on recognition and understanding of differences between sets of line drawn pictures. At age 9, children took the Schonell and Adams essential intelligence test form A or B, which primarily measured reading ability. Age standardised IQ scores were derived from the test results and were normalised to a national mean of 100 (SD 15; see bmj.com).

Data on singleton or multiplet status, mother's age at delivery (in five year age bands), birth weight (to the nearest 0.5 pounds), gestational age (in completed weeks based on date of last menstrual period), and father's occupational social class at the time of delivery were abstracted from the Aberdeen maternity and neonatal databank at the time of the 1962 survey. We measured each child's intrauterine growth rate by their birth weight for gestational age z score. We used sex specific mean and standard deviations of birth weight for each completed week of gestation among all births in the study for our calculation. We obtained information on the number of older siblings from the questionnaire administered by the original study team in 1962. For the purposes of this analysis we assigned both members of a twin pair the birth order of the firstborn twin.

Statistical methods

We compared the mean IQ values measured at ages 7 and 9 years of singletons and twins overall and across categories of potential confounders. We used analysis of variance to assess the significance of differences between groups and linear trends in mean IQ values.

To account for sibling correlations we used random effects linear regression models to calculate crude overall mean differences in IQ between twins and singletons. We used fixed effects linear regression to estimate differences within families in mean IQ of twins and singletons. We adjusted for observed potential confounders by introducing them into the models, at first separately and then jointly.

We modelled IQ as a continuous dependent variable. Birth weight, gestational age, and birth weight z score seemed to have non-linear associations with IQ. We therefore included these variables as either categorical variables or as continuous variables, transformed according to the best fitting polynomial function (see bmj.com).

Results

Of the 12 150 members of the children of the 1950s cohort, 10 were triplets, 306 were twins, and 11 834 were singletons. Of the twins and singletons, 10 068 participants had complete data, whom we included in multivariable regression analyses (9832 singletons and 236 twins, together belonging to 8160 families).

Participants excluded from our study had a significantly ($P < 0.001$) lower mean score at age 7 than those included. The IQ difference was 7.4 points (95% confidence interval 6.6 to 8.3). They also had a significantly ($P < 0.001$) lower mean score at age 9 (IQ difference 5.5 points, 4.6 to 6.5), partly explained by the fact that a proportion would have been in special schools where the standard test was not routinely given. Subjects with missing gestational age included a disproportionate number with low birth weight, which is associated with impaired later cognition.

Twins tended to be born smaller and earlier in gestation than singletons and also to be born smaller for

Table 2 Mean differences (95 confidence intervals) in IQ within families between singletons and twins, at ages 7 and 9

Adjustment for confounders within families	At age 7	At age 9
None	5.3 (1.5 to 9.1)	6.0 (1.7 to 10.2)
Sex	5.3 (1.6 to 9.1)	6.0 (1.7 to 10.2)
Maternal age at delivery	5.5 (1.8 to 9.3)	6.2 (1.9 to 10.5)
No of older siblings	5.1 (1.3 to 8.9)	5.3 (1.0 to 9.6)
Birth weight (continuous)	2.8 (−1.3 to 6.9)	4.3 (−0.3 to 8.9)
Gestational age (continuous)	4.7 (0.8 to 8.6)	5.7 (1.3 to 10.1)
Birth weight z score (continuous)	4.0 (0.1 to 7.9)	5.0 (0.6 to 9.4)
Sex, maternal age at delivery and No of older siblings	5.4 (1.6 to 9.3)	5.7 (1.4 to 10.0)
Birth weight and gestational age (continuous)	2.6 (−1.5 to 6.7)	4.1 (−0.5 to 8.8)
Birth weight z score and gestational age (continuous)	2.9 (−1.2 to 7.0)	4.3 (−0.3 to 8.9)

their gestational age. Twins had a greater number of older siblings than singletons on average, indicating that mothers with higher parity (and hence older age) were more likely to deliver twins. The difference in the distribution of father's social class between twins and singletons did not reach significance ($P = 0.35$; see bmj.com).

We found that singletons had significantly higher mean IQ scores than twins ($P < 0.001$ at both ages). The crude overall difference was 6.6 points at age 7 (4.4 to 8.8) and 6.9 points at age 9 (4.5 to 9.2). IQ at both ages showed positive linear trends, and for both singletons and twins, across categories of birth weight and gestational age, while we found a graded inverse trend with number of older siblings and paternal social class (although this was weaker among twins).

As table 1 shows, sex, maternal age, number of older siblings, and father's social class at birth explain little of the mean IQ difference between twins and singleton at either age. However, adjustment for birth weight, gestational age, or birth weight z score reduces these differences substantially. The results, however, are still potentially confounded by unmeasured shared maternal and family characteristics that can be controlled for when computing effects within families. Table 2 shows unadjusted differences within families in mean IQ between twins and singletons that are only slightly smaller than the equivalent ones of table 1. The difference in mean IQ between singletons and twins was again reduced substantially when controlled for birth weight. This adjusted estimate was similar to that produced by simultaneous adjustment for birth weight and gestational age.

Discussion

Consistent with other studies we found strong evidence of an appreciable cognitive deficit, of more than 6 IQ points, in twins compared with singletons at ages 7 and 9, among children who attended primary school in Aberdeen in 1962. We have also shown that differences in IQ between twins and singletons of the same order are found within families. These differences persisted after adjustment for maternal age and number of older siblings. We also replicated associations between cognition, socioeconomic position, and size at birth, and differences between twins and singletons in maternal age and birth order that have been well established in the literature, which led us to conclude that our data have a basic validity.

Limitations of the study

Firstly, the cognitive tests were given in school supervised by class teachers and not by researchers. Secondly, we excluded almost 20% of subjects because of missing data. However, it is difficult to imagine how this may have biased our key findings, particularly with respect to differences between twins and singletons within families. Finally, we had limited information on potential confounders. However, many of the potentially important confounders that are missing, such as parental IQ, cannot have any role in explaining the effects within families.

What is already known on this topic

Intelligence in childhood is predictive of educational attainment, socioeconomic position, and health in adulthood

Twins have a lower IQ in childhood than singletons, which has not been adequately accounted for by confounding by maternal characteristics or family and socioeconomic environment

No previous studies have investigated how far this difference in IQ between twins and singletons is due to fetal growth

What this study adds

On average, twins have lower IQ scores at ages 7 and 9 than singleton children in the same family

The lower intelligence of twins in childhood may partly be a consequence of the reduced fetal growth and shorter gestations of twins

The size of the differences between twins and singletons in the overall analysis was very similar to that found in the within family analysis, and paternal social class, maternal age, and number of older siblings seem to show very little confounding effect. This means that these differences cannot be explained by the characteristics of families who have twins and those who do not. Nevertheless it is still possible that other aspects of non-shared postnatal environment between twins and singletons may have an important role in explaining the observed IQ differences within families.

Comparison with other studies

Our results are in disagreement with the only sizeable study that compared twins and singletons in the same family.[5] This discrepancy may well be explained by recruitment bias. Posthuma et al drew their sample from adults in the Netherlands twin registry. The index twins who agreed to take part in that study are unlikely to have been representative of the total population of twins. In particular, those with lower IQs are likely to have been under-represented. The singletons who were recruited by their twin siblings would not have been subject to such a strong bias. This would have led Posthuma et al to underestimate the twin deficit in cognition relative to our population cohort study.

We took our analyses further than others by exploring whether the adverse effect of twinship on cognitive development can be attributed to the impaired growth of twins in the womb and their shorter average gestations.

Our findings are consistent with the positive association between birth weight and IQ that has been shown in several studies.[8–11] Sharing the intrauterine environment, including the nutrient supply, with a co-twin may impair cognitive, as well as somatic, development. On the other hand, cognitive disadvantage may be incurred later in development and be associated with size at birth because of tracking of growth through childhood. Alternatively, effects of the intrauterine environment may be part of a chain of developmental events leading to the accumulated deficit in IQ in twins by age 7.

Conclusions

Cognitive ability is strongly associated with educational attainment, adult socioeconomic position, and mental and physical health. A cognitive deficit in twins of this magnitude is therefore clearly of long term importance. However, our observations are based on a cohort born more than 50 years ago. Whether the effects today are as large requires study of a more contemporary cohort.

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Ethics approval: The Scottish multicentre research ethics committee and local research ethics committees and the Scottish privacy advisory committee approved the revitalisation of the children of the 1950s cohort. All record linkage was undertaken by Information Services Division (Edinburgh), which provided us with an anonymised dataset for analysis.

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A very "patient" me

Late one evening I felt a headache split my forehead. I took a paracetamol, hoping it would disappear. It didn't, and a few hours later a raging fever took over. A colleague had me packed to the hospital, where I was found to have mixed malaria, falciparum and vivax.

As I responded to one drug and reacted against another, a suitable combination was eventually arrived at, and I was pronounced ready for discharge nine days after admittance. I was euphoric. Scores of visitors had dropped by, and "Get well" cards littered the room. Many students came to enjoy the sight of a temporarily dysfunctional "AK-47"—my nickname for spewing anatomy viva questions in rapid fire mode.

The next few hours were exasperating, while I waited to be discharged. At three in the afternoon, I asked the nurse when my discharge would come through. "In an hour," she replied. It would be good to be back in circulation. Another hour passed, and still no moves to get me out. I called the physician—"Hold on, just paperwork," I was told. Suddenly, my drips and drugs were removed, but the interminable "defer release" drama continued. Why wasn't I home by now? It was time to play AK-47: I demanded discharge, now.

Shortly after, a nurse strutted in and, to my amazement, reset the drips and had me back on the infernal metal cot. A relapse? "I want to check the smear myself," I shouted as the nurse shut the door gently behind her.

Then at 5 pm, amid much fanfare, more visitors arrived; heading the delegation was my university's vice-chancellor. He inquired about my progress, clucking sympathetically to my grouchy replies. Presently, he patted my shoulder, wished me well, handed over a bouquet, instructed the staff to look after me well, and left.

Within a minute, the nurse returned giggling uncontrollably. She ripped out the drips and stripped off the plaster with much gusto. "You can go," she said, slamming the door laughing as she left. I later learnt that the vice-chancellor had wanted to visit me, and so the hospital had enacted the "defer this discharge" charade, reattached the drips, and tucked me up to my chin in mournful green blankets to make me seem appropriately pathetic. No sooner had he gone, than I was deemed fit again.

Strange are the ways that patients are managed. The vice-chancellor was happy when he heard that his visit had been such a tonic for me that I had mended astoundingly rapidly. The hospital was euphoric with its theatrical success.

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We welcome articles up to 600 words on topics such as *A memorable patient, A paper that changed my practice, My most unfortunate mistake,* or any other piece conveying instruction, pathos, or humour. Please submit the article on http://submit.bmj.com Permission is needed from the patient or a relative if an identifiable patient is referred to. We also welcome contributions for "Endpieces," consisting of quotations of up to 80 words (but most are considerably shorter) from any source, ancient or modern, which have appealed to the reader.