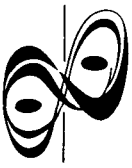

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Twins: Are They at Risk?

A Longitudinal Study of Twins and Nontwins from Birth to 18 Years of Age

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Abstract. The purpose of this study has been a comparison of a group of twins (145 pairs) and a whole cohort of singletons (114,828 individuals) born 1953 and living in the Stockholm metropolitan area in 1963. The twins and singletons have been followed from birth onwards. A pertinent question is whether twins are at greater risk at birth and whether they are predisposed to below-average mental and physical growth. The results show that twins are more susceptible to lower birth weight, shorter gestation period and birth complications. These factors also seem to have a lasting effect on later physical and mental development. Monozygotic twins, twin girls, and male twins with low birth weight, seem to be particularly at risk for below-average mental and physical growth. An interaction between social background and birth weight can also be seen for the male twin group.

Key words: Twins, Development, Risk

INTRODUCTION

Many researchers have pointed out that a "twin handicap" is evident in grown-up twins concerning both physical and mental growth [12]. Twins tend to be shorter and weigh less, and also to have somewhat lower average achievement in mental test scores. In a large longitudinal Swedish twin study involving around 300 twin pairs, Fischbein and Lindgren [8] found, however, that there was only a slight and nonsignificant difference in height and weight between twin boys and singleton controls at the age of 10-18 years. For twin girls, on the other hand, there was a difference during this period, so that the twin girls were significantly shorter and weighed less than their controls. There were no

differences between MZ and DZ twins in physical growth during puberty. Similar results were found for mental growth and school achievement [4]. Twin girls showed lower average achievement test results compared to singleton control girls of the same age. For boys, there was a significant difference between twins and controls only for verbal and nonverbal ability tests. It thus would seem that, not only do twins show a slight "handicap" in verbal ability, which has often been reported [14], but also that this can be found for other types of ability tests.

For grown-up twins, there is very little evidence of these types of comparisons. Husén [12] reports a trend for twin boys to have lower average scores on ability tests at 20 years of age. Also, the variation in test scores seemed to be larger for the twins compared to male singletons of the same age. A twin group with very low scores thus tends to decrease the average score for the whole twin population. Husén did not find any significant differences between MZ and DZ male twins at the age of 20.

Summarizing the research findings, it could be said that there seems to be a "twin handicap" concerning both physical and mental growth. This is more evident for twin girls than for twin boys. One explanation might be that twin girls, to a greater extent than twin boys, tend to survive birth complications and also to attend school in a regular class. This might imply that a sample of twin boys is a more selective group than twin girls. It is also possible that twin girls are more dependent upon each other, spend more time together and therefore have fewer opportunities to receive stimulation from grown-ups and other children [10]

An interesting question is also what will happen if birth complications are becoming less serious for twins. Refined technique and more advanced neonatal care will probably lead to fewer birth complications at twin births. Recent research indicates that this might decrease the "twin handicap" and perhaps also reduce existing sex differences [1,9].

It has been discussed by several researchers whether the size of a "twin handicap" is related to social background or not. It could be argued that a more stimulating and favourable home environment might reduce or even abolish an existing difference between twins and nontwins. Zazzo [19], Koch [14], Mittler [16] and Fischbein [5] have presented results indicating a difference irrespective of social background. Heisterkamp [11] found, however, a larger difference between twins and controls from lower social classes compared to higher. Wilson [17,18] compared twins with low (< 1750 g) and normal birth weight from different social groups. He found that the difference on a mental growth test between low birth weight and other twins was larger in lower social classes and tended to disappear in higher social classes. This could of course be a result of both genetic and environmental causes.

It can be seen that there are some contradicting research results concerning a) if twins are at greater risk than nontwins and b) if there is a persisting "handicap" for twins in physical and mental growth. A longitudinal Swedish growth study, Project Metropolitan [13], offers certain possibilities to follow twins from birth onwards and to relate birth complications to future development until 18 years of age. The twins can also be compared to a large and representative population of non-twins born and living in the Stockholm area 1963.

The purpose of this comparison will be to study risk factors at birth for the twins and to determine whether such factors influence their future development. Also, it will be of interest to relate this to the social background of the twins.

MATERIALS AND METHODS

Project Metropolitan is a longitudinal study comprising 15,117 individuals born 1953 and living in the Stockholm area 1963. They were sampled and registered ten years later, 1 November 1963. The cohort consists of 7,719 boys and 7,398 girls. Birth registers at the hospitals in Stockholm supplied information on complications during pregnancy for the mother and additional data concerning delivery of the children. This means that birth records are missing for children born outside the Stockholm area [13]. Information was also collected concerning parental occupation, place of birth and date of marriage.

In 1966, a school study was conducted on the cohort, at that time attending grade 6. Two questionnaires were used. One consisted of three ability tests (opposites, metal folding, and number series) as well as questions about interests, attitudes toward school, leisure activities and future educational plans. The other questionnaire concerned sociometric choices and questions about school, leisure time and occupational plans. The questionnaires were administered by the teachers in the classrooms with the help of interviewers from the Central Bureau of Statistics. In addition to the questionnaires, marks and absence from school were registered.

After leaving compulsory school in grade 9, the cohort could go either three or four years in gymnasium or attend a more practical 2-year stream, called "fackskolan". These choices have also been registered for the Metropolitan group. At the time of enrollment to military service for the boys, some complementary data were also collected. These concerned primarily physical and mental capacity measures. A thorough description has been given by Jansson [13].

Project Metropolitan includes 145 twin pairs (ie, 1:93 pairs, or 1.07%), 120 of which are born in the Stockholm area. For the like-sexed pairs, a zygosity classification has been made by means of the twin register at the Karolinska Institute: 28 pairs were classified as MZ, 53 as DZ, and 14 pairs could not be classified. A similarity diagnosis has been used which has been described by Medlund et al [15].

RESULTS

Parental Information

Table 1 illustrates mother's age at birth for twins and singletons in project Metropolitan. The results show that mothers of twins are older than mothers of singletons. Around 52% of the former are older than 30 years at the birth of the twins, while only about 40% of the singletons' mothers are of this age. The mean age is 29.4 vs 28.4 years and this difference is significant ($p < 0.01$).

Table 2 shows the social background of the parents in the Metropolitan project. Two twins are not included in the cohort. The data therefore include 288 twins (144 pairs). Around 40% of the parents (38.9% of parents of singletons and 36.2% of parents of twins) belongs to the working class while slightly more are classified as higher or middle class.

Table 1 - Mother's age at birth

	15-19 yr	20-24 yr	25-29 yr	30-34 yr	35-39 yr	40-44 yr	45-49 yr	Total	No answer
Twin boys	4	17	46	53	26	7	—	155	—
Twin girls	4	13	52	45	16	3	—	133	—
Total	8	30	98	100	42	10	—	288	—
%	2.8	10.3	34.4	34.6	14.5	3.4	—	100	—
Metropolitan boys	363	1747	2334	1928	879	276	19	7546	18
Metropolitan girls	306	1765	2276	1769	851	257	27	7251	13
Total	669	3512	4610	3697	1730	533	46	14797	31
%	4.5	23.7	31.2	25.0	11.7	3.6	0.3	100	—

Table 2 - Social background of parents

	Higher/ middle class	Lower/ middle class	Free occupa-tions	Manual workers (educated)	Manual workers (uneducated)	Total	No answer
Twin boys	25	64	8	29	22	148	7
Twin girls	15	50	16	27	23	131	2
Total	40	114	24	56	45	279	9
%	14.3	40.9	8.6	20.1	16.1	100	—
Metropolitan boys	1270	2614	547	1656	1243	7330	234
Metropolitan girls	1277	2512	584	1593	1128	7094	170
Total	2547	5126	1131	3249	2371	14424	404
%	17.7	35.5	7.9	22.5	16.4	100	—

Birth Data

Table 3 gives the registered complications at birth for mothers of twins and of singletons. As expected, twin births tend to imply more complications for the mother than ordinary births. Almost 40% of the twin births were complicated vs 16% of births of one child. The difference between births of twin girls and twin boys is very small and can be disregarded. Types of complications are, eg, bleedings or excessive duration of delivery. Also for the children different types of complications at birth have been registered, eg, incorrect position at birth or asphyxial problems. Such complications also tend to be more frequent at twin births vs singleton births.

One factor that contributes to birth complications in twins is of course that more twins are born prematurely compared to singletons. The average time of pregnancy is 266 days in mothers of twins vs 281 in mothers of singletons. Thus, twins are born on average two weeks earlier than nontwins: 54% of the twins are born earlier than 269 days of pregnancy (vs 14.7% of singletons) and 10.6% of the twin children are born during the seventh month of pregnancy.

Table 3 - Birth complications for mothers of twins and singletons

	No complications	Complications	Total	No answer/ Not born in Stockholm area
Twin boys	81	48	129	26
Twin girl	68	39	107	26
Total	149	87	236	52
%	63.1	36.9	100	—
Metropolitan boys	5085	992	6077	1487
Metropolitan girls	4909	896	5805	1459
Total	9994	1888	11882	2946
%	84.1	15.9	100	—

Table 4 shows the birth weights of twins and singletons in the Metropolitan Project. It can be seen that the most frequent birth weight for the twins varies between 2.0 and 3.0 kg (65.1%), vs 3.0-4.0 kg in singletons (68.5%). The average birth weight for both twin girls and twin boys is 2.6 kg and for the Metropolitan singletons 3.5 kg ($p < 0.01$). In the group of singletons, the boys tend to be somewhat heavier ($p < 0.05$).

From the birth data presented here it can be concluded that twins tend to be born prematurely and weigh less than singletons. Birth complications are also more prevalent in twins than singletons.

Table 4 - Birth weight (g) of twins and singletons

	<2000	2000-2499	2500-2999	3000-3499	3500-3999	4000-4499	4500-4990	>5000	Total	No answer/ Not born in the Stockholm area
Twin boys	8	37	50	21	8	1	1	1	127	28
Twin girls	14	29	35	20	7	0	0	0	105	28
Total	22	66	85	41	15	1	1	1	232	56
%	9.5	28.4	36.7	17.7	6.5	0.4	0.4	0.4	100	—
Metropolitan boys	46	103	473	1726	2332	1112	241	26	6059	1505
Metropolitan girls	30	117	660	2061	1998	773	131	18	5788	1476
Total	76	220	1133	3787	4330	1885	372	44	11847	2981
%	0.6	1.9	9.6	32.0	36.5	15.9	3.1	0.4	100	—

School Data

Table 5 compares ability test results for twins and singletons in grade 6. It can be seen that differences between DZ twins of the same and of different sex are small and insignificant. MZ twins tend, however, to get lower average scores on all the ability tests.

The differences between MZ and DZ twins are significant for the verbal ($p < 0.01$) and the spatial ($p < 0.05$) tests, while there is a small and insignificant difference for the numerical test results. In comparison to nontwins, both twin girls and twin boys have lower average scores. For the twin boys, however, only the verbal test scores show a significant difference ($p < 0.01$). For the twin girls, both the verbal and the numerical tests show significant differences ($p < 0.01$). The differences are generally more conspicuous for the girls.

Table 5 - Ability test scores for twins and singletons in grade 6

	Verbal test results			Spatial test results			Numerical test results		
	X	SD	N	X	SD	N	X	SD	N
MZ	21.02	7.01	48	20.73	7.15	48	17.82	8.08	50
DZ-SS	22.87	6.44	98	22.09	6.98	98	19.13	8.28	98
DZ-OS	23.43	6.36	91	22.41	6.80	91	19.94	7.74	91
Twin boys, UZ	21.00	7.77	13	22.61	9.56	13	20.00	9.71	13
Twin girl, UZ	23.90	6.78	10	24.50	4.95	10	19.50	6.21	10
Twin boys	22.90	6.65	135	22.75	7.41	135	20.09	8.49	135
Twin girls	22.42	6.68	125	21.34	6.60	125	18.30	7.52	127
Metropolitan boys	24.57	6.65	6673	23.32	7.37	6672	21.18	8.32	6669
Metropolitan girls	24.84	6.90	6504	22.10	6.83	6503	20.35	7.85	6500

SS = same sex; OS = opposite sex; UZ = unknown zygosity.

Table 6 gives the results for twins and singletons concerning average marks in grades 6 and 9. For several individuals, marks are missing in the 9th grade. This is due to some of them having moved out of the Stockholm area. Others have made a break after grade 8. Some classes have got no marks at all.

Table 6 - Average marks[a] for twins and singletons in grades 6 and 9

	Marks					
	Grade 6			Grade 9		
	X	SD	N	X	SD	N
MZ	3.13	0.74	56	2.94	0.88	51
DZ-SS	3.25	0.71	101	3.26	0.63	89
DZ-OS	3.19	0.65	92	3.22	0.79	91
Twin boys, UZ	3.15	0.69	14	3.44	0.72	4
Twin girls, UZ	3.30	0.69	10	3.47	0.81	7
Twin boys	3.12	0.65	145	3.27	0.73	128
Twin girls	3.30	0.72	128	3.11	0.79	121
Metropolitan boys	3.12	0.70	7056	3.13	0.79	6581
Metropolitan girls	3.34	0.68	6862	3.22	0.76	6585

[a] Marks in physical education not included.
SS = same sex; OS = opposite sex; UZ = unknown zygosity.

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MZ twins tend to get lower average marks than DZ twins both in grade 6 and 9. This difference is, however, only significant in grade 9 ($p < 0.05$). For the total twin group there is, however, no difference with respect to singletons in grade 6. In grade 9, the difference between twins and controls is significant for boys ($p < 0.05$) but not for girls. Girls generally tend to get higher average marks than boys, which has been found in many other studies [3]. This sex difference is not evident, though, for twins in grade 9, which is another indication of a slight handicap for the twin girls.

In summary, there seem to be some differences between twins and singletons in ability test results. Twin girls, in particular, show lower test scores than girls in general do. This trend is not evident when looking at average marks in grade 6 and 9, where the twins seem to be equal to their classmates.

Military Enrollment Data

A comparison of male twins and singletons can be made at their enrollment in military service at the age of 18. Height and weight, as well as physical capacity and ability test results, are available for twins and singletons at this age.

Table 7 shows that differences in height between grown-up male twins and singletons are smaller than for weight but still significant (height, $p < 0.05$; weight, $p < 0.01$).

Table 7 - Average height and weight for twins and singletons at military enrollment

	Height			Weight		
	X	SD	N	X	SD	N
MZ	179.36	6.06	30	64.46	10.25	28
DZ	178.60	6.77	100	64.24	8.30	100
Twin boys, UZ	176.27	3.59	15	60.67	3.89	15
Total	178.51	6.35	145	63.91	8.39	143
Metropolitan boys	179.67	6.62	6434	66.97	10.64	6434

Muscular strength and physical work capacity were also measured and the results are presented in Table 8 for male twins and singletons. There is a significant difference between twin boys and other boys in muscular strength at age 18 ($p < 0.01$). The twins show a somewhat lower average also in physical work capacity, but this difference is not significant.

In several other twin studies a persisting "handicap" has been found for grown-up twins in mental capacity. Table 9 shows that the differences between twins and singletons are small for all the tests. For verbal-inductive and spatial ability, as well as technical reasoning, however, the differences in average test scores are significant ($p < 0.05$). It could be maintained that differences in ability test scores at age 13 have decreased at age 18. These differences were, however, larger for the girls and the results presented here are only including boys.

Table 8 - Average muscular strength and physical work capacity for twins and singletons at age 18

	Muscular strength (newton)			Physical work capacity (watt)		
	X	SD	N	X	SD	N
MZ	4.68	1.74	28	5.00	1.74	28
DZ	4.78	1.54	100	5.48	2.08	100
Twin boys, UZ	4.27	0.80	15	6.60	1.50	15
Total	4.70	1.53	143	5.50	2.01	143
Metropolitan boys	5.19	1.69	6454	5.72	1.91	6441

UZ, unknown zygosity.

Table 9 - Average test scores for twins and singletons in apperception, verbal-inductive ability, spatial ability and technical reasoning at age 18

	Apperception			Verbal-inductive ability			Spatial ability			Technical reasoning		
	X	SD	N	X	SD	N	X	SD	N	X	SD	N
MZ	5.04	1.97	28	5.21	1.73	28	5.71	1.86	28	4.96	2.59	28
DZ	5.24	1.75	101	5.11	1.80	101	5.59	1.62	101	4.67	1.82	101
Twin boys, UZ	4.60	2.03	15	4.73	2.09	15	6.13	2.03	15	4.6	2.26	15
Total	5.14	1.76	144	5.09	1.75	144	5.67	1.65	144	4.72	1.95	144
Metropolitan boys	5.39	1.86	6500	5.42	1.96	6499	6.01	1.78	6499	5.04	1.99	6499

UZ = unknown zygosity.

A conclusion, based on results from military enrollment data, is that differences between male grown-up twins and singletons are for the most part very small. The largest differences are found for weight and physical strength.

The Importance of Birth Weight and Social Background for Mental Growth in Twins

It is of special interest to study if the special complication of low birth weight will contribute to a persisting handicap in mental growth. Thus, tables 10 and 11 illustrate ability test scores at age 13 and 18 controlling for birth weight. The tables show lower average scores on all types of tests at age 13 and 18 for low birth weight twins. At age 13, where a comparison between sexes is possible, this difference is larger for boys ($p < 0.05$). At age 18, all test scores, except spatial ability scores, show significantly lower results for

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Table 10 - Average ability test results for twins at age 13 controlling for birth weight

Birth weight (kg)	Verbal ability			Spatial ability			Numerical ability		
	X	SD	N	X	SD	N	X	SD	N
Boys									
<2.5	20.40	6.23	45	20.71	7.61	45	17.80	9.10	45
≥2.5	23.82	6.31	68	24.40	6.33	68	21.77	7.76	68
Girls									
<2.5	21.89	6.00	46	20.94	6.91	46	17.67	6.92	46
≥2.5	22.89	7.23	54	22.07	6.47	54	18.52	8.35	54

low birth weight twins ($p < 0.05$). Average differences in marks are smaller than for test results, especially in grade 9. Low birth weight in twins thus seems to have a persisting influence on future test results.

Table 11 - Average ability test results for male twins at age 18 controlling for birth weight

Birth weight (kg)	Apperception			Verbal-inductive ability			Spatial ability			Technical reasoning		
	X	SD	N	X	SD	N	X	SD	N	X	SD	N
<2.5	4.68	1.68	44	4.27	1.68	44	5.34	1.76	44	3.93	1.87	44
≥2.5	5.37	1.99	75	5.45	1.82	75	5.79	1.76	75	5.01	2.00	75

Social background is, as expected, related to test results and marks for twins as well as for nontwins. A pertinent question is, however, whether a more stimulating home environment might compensate for the handicap in mental growth shown by low birth weight twins. Table 12 presents ability test results and marks controlling for birth weight and social background.

Social background seems to be more important for boys than for girls. Low birth weight working class boys have lower average scores than low birth weight boys with higher/middle class background. Only the numerical ability test shows a significant difference ($p < 0.05$) between the groups, however. The differences for twin girls are smaller or non-existent. In the twin group with normal birth weight, social background is of equal importance for both boys and girls, which means that differences in average test scores between the socioeconomic groups are significant ($p < 0.05$) for both boys and girls (with the exception of numerical ability test scores).

Table 13 illustrates the same type of results for twin boys at age 18 at the enrollment to military service. The trend seen at age 13 is evident for the twin boys also at age 18. Three test results out of four show significant differences (apperception, spatial and technical reasoning, $p < 0.05$) between the socioeconomic groups in the normal birth weight group. In the low birth weight group, however, only spatial ability shows a sig-

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Table 12 - Ability test results and marks for twins controlling for birth weight and social background

	Working class						Higher/middle class					
	Boys			Girls			Boys			Girls		
	X	SD	N	X	SD	N	X	SD	N	X	SD	N
Low birth weight (<2.5 kg) twins												
Age 13												
Verbal ability	18.21	6.67	14	22.47	7.31	19	21.82	4.91	27	21.48	4.99	27
Spatial ability	18.86	7.37	14	19.74	7.36	19	22.63	6.60	27	21.78	6.58	27
Numerical ability	14.21	6.93	14	17.32	7.61	19	19.33	9.33	27	17.93	6.53	27
Average marks	2.96	0.55	13	3.29	0.68	19	2.96	0.60	31	3.19	0.61	28
Age 16												
Average marks	3.15	0.81	11	3.12	0.63	18	3.30	0.67	25	3.05	0.67	27
Normal birth weight (≥2.5 kg) twins												
Age 13												
Verbal ability	20.88	6.67	24	20.14	6.37	21	25.43	5.55	44	24.50	7.23	34
Spatial ability	22.25	6.37	24	19.29	7.52	21	25.57	6.06	44	23.44	5.52	34
Numerical ability	18.21	7.07	24	26.24	8.92	21	23.71	7.50	44	19.91	7.65	34
Average marks	2.85	0.43	26	3.13	0.53	21	3.39	0.68	45	3.60	0.88	33
Age 16												
Average marks	2.93	0.61	25	2.79	0.68	18	3.37	0.73	41	3.42	0.96	32

Table 13 - Ability test results for male twins at age 18 controlling for birth weight and social background

	Twins of low birth weight (<2.5 kg)						Twins of normal birth weight (≥2.5 kg)					
	Working class			Higher/middle class			Working class			Higher/middle class		
	X	SD	N	X	SD	N	X	SD	N	X	SD	N
Apperception	4.18	1.63	17	4.90	1.83	31	4.75	2.11	24	5.93	1.72	42
Verbal-inductive ability	4.00	1.23	17	4.58	1.75	31	5.08	1.93	24	5.74	1.71	42
Spatial ability	4.82	1.47	17	5.74	1.77	31	5.04	1.85	24	6.17	1.68	42
Technical reasoning	3.71	1.80	17	4.32	1.97	31	4.33	2.10	24	5.45	1.90	42

nificant difference between the socioeconomic groups ($p < 0.05$). A stimulating home environment thus seems to compensate for low birth weight for boys, but not for girls, both at age 13 and 18.

DISCUSSION

The main purpose of this paper has been to study birth complications for twins and possible consequences for their future development. A comparison has been made with a whole cohort of singletons in the Metropolitan Project.

In agreement with previous studies [1], it was found that twin mothers, on average, are older than mothers of singletons and that birth complications are more frequent for the twin group. A lower average birth weight is one factor contributing to such complications.

In the comparison of school achievement and ability test results at age 13, 16 and 18, between twins and singletons, MZ twins, and particularly twin girls, tend to be at a disadvantage. This has also been found in earlier twin studies [5]. The reason for this is not clear, but twin boys might be a more highly selected group, or the greater dependency of twin girls on each other [6] might influence intellectual development. At age 18, a comparison has only been possible for the boys. A twin handicap in mental as well as physical growth can be found in grown-up male twins compared to singletons.

Low birth weight (< 2.5 kg) also seems to have a lasting impact on mental development. In particular, twin boys with low birth weight seem to be at a disadvantage. This difference tends to disappear, however, in a more stimulating home environment. No such effect can be seen for the twin girls with a low birth weight.

In summary, we have shown that twins are at a risk at birth in comparison with singletons and that this also has an impact on their future development. There is, however, a substantial overlap between the two distributions, and most twins develop in parity with their age-mates. Moreover, MZ twins, twin girls, and low birth weight twin boys, appear to be particularly at risk. On the other hand, it should be kept in mind that neonatal care has made a significant progress during recent years, so that we might get a different result today when comparing twins and singletons [2,7].

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