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Within-pair Similarity in MZ and DZ Twins from Birth to Eighteen Years of Age

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Abstract. This study is based on 145 pairs of twins included in a longitudinal study of a cohort of singletons born in 1953 and living in the Stockholm metropolitan area in 1963. Of these 145 pairs, 28 were classified as MZ, 103 as DZ and 14 pairs could not be classified. School achievement and ability test results have been collected for this group as well as data for the boys from physical and mental examinations on enrollment to military service. The purpose of this study was to compare within-pair similarity for MZ and DZ twins from birth onwards. There seems to be a divergent trend over time for MZ twin pairs to become more similar and DZ twin pairs to become less similar in height growth, school achievement and verbal ability. This is in accordance with previous research in this field. In relating similarity within pairs to birthweight, we found a drop in within-pair similarity for low birthweight MZ and DZ twin pairs (both twins ≤ 2.500 g), but not for normal weight twin pairs. A discussion is initiated concerning methodological implications of these results.

Key words: Twins, Low birthweight, Physical growth, Heredity-environment influences

INTRODUCTION

Wilson [16] has reported within-pair comparisons for *height and weight* growth from birth onwards for monozygotic (MZ) and dizygotic (DZ) twins. Initially DZ twins seem to be more similar in height and weight than MZ twins [5]. The latter, however, with age tend to become progressively more concordant for height and weight. Several studies have also shown a discordant trend in within-pair similarity for DZ twins in weight growth during puberty [4,7,12]. In an Indian study by Sharma [11] a slightly different trend is visible. He finds no continuous discordant trend for the male and female DZ intrapair correlations neither for height nor for weight. He suggests that this might be due to “differential cultural practice besides other environmental factors” (op. cit.).

Within-pair similarity in *mental growth* for MZ and DZ twins from birth up to school age has also been reported by Alin Åkerman [3] and Wilson [13-15,17]. MZ twins became increasingly concordant with age and matched each other closely for developmental trends. By contrast, dizygotic twins regressed to an intermediate level of concordance. Fischbein [8] has shown the same trend for verbal ability as well as school achievement at puberty. For logical reasoning the differences in within-pair similarity for MZ and DZ male twins tended to be of the same magnitude from 10 to 18 years of age.

A comparison of low birthweight twins with varying social backgrounds has shown an interactional effect between birthweight and social background. Low birthweight twins (<1750 g) from a higher social class background were comparable to normal birthweight twins at 6 years of age, while those from a lower social background were far below in mental growth at 6 years of age [18].

Results from the Metropolitan project reported here [9] offer the possibility to compare within-pair similarity for MZ and DZ twins from birth to 18 years of age for the same sample of twins. These will also enable us to test the results found by Fischbein [7] on another sample. In addition to this, later physical and mental growth can be related to low birthweight and other birth complications. Birth complications according to Alin Åkerman and Fischbein [1] seem to have a lasting effect on physical and mental development.

The aim of this study is to compare similarity within MZ and DZ twin pairs in both physical and mental development from birth onwards. Two hypotheses based on earlier twin research are proposed:

1. The difference in within-pair similarity for MZ and DZ twins will increase in physical and mental growth from birth to 18 years of age.
2. The difference in physical and mental growth for MZ and DZ twins is related to low birthweight and other birth complications.

MATERIALS AND METHODS

Project Metropolitan [9] is a longitudinal study comprising 15,117 individuals born in 1953 and living in the Stockholm area. They were sampled and registered ten years later, 1963. The study consists of 7,719 boys and 7,398 girls. Birth registers at the hospitals in Stockholm supplied information on complications for the mother during pregnancy and additional data concerning delivery of the children.

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 interests and attitudes toward school. The data were collected by the teachers in the classrooms with the help of interviewers from the Central Bureau of Statistics. Marks were taken from school registers in grades 6 and 9.

On leaving compulsory school in grade 9, the cohort could either go for three or four years to a gymnasium or else attend a more practical 2-year stream, called "fackskolan". For the boys, some complementary data were also collected on enrollment to military service. These concerned primarily physical and mental capacity measures.

The project included 145 twin pairs (1.07% of the population), 120 of which were

born in the Stockholm area. Birth data were only available for 103 twin pairs. For 3 pairs data for one twin only were available. These were not included in birth data comparisons. For 14 pairs it was not possible to make a zygosity classification.

In our study we present intra-class correlation coefficients for the MZ and DZ twin pairs based on variance analyses [10]. These within-pair comparisons were made for height and weight at birth, and again at 18 years of age for the boys. We also compared within-pair similarity for MZ and DZ twins in mental growth during and after puberty and relate these results to low birthweight data.

RESULTS

I. Comparisons of physical growth in MZ and DZ twins

Table 1 illustrates height and weight at birth for MZ and DZ twins. The 3 pairs with missing birth data for one twin are not included in the table. The twins, both MZ and DZ, are around 47 cm tall and weigh around 2.6 kg at birth. The results show no significant difference in height and weight between monozygotic and dizygotic twins.

Table 1 - Height (cm) and weight (kg) at birth for MZ and DZ twins

	MZ			DZ			t
	X	S	N	X	S	N	
Height	47.47	2.69	38	47.24	3.27	168	0.45
Weight	2.59	0.51	38	2.68	0.60	168	1.05

Table 2 illustrates within-pair correlations for height and weight at birth. Both height and weight correlations are around 0.80 with somewhat higher correlations for height than for weight. The within-pair correlations are practically the same for MZ and DZ twins for both height and weight. In this sample, DZ twin pairs seem to be even somewhat more similar in height at birth than MZ twins.

Table 2 - Within-pair correlations for height and weight at birth

	MZ		DZ	
	r	No. pairs	r	No. pairs
Birth height	0.81	19	0.86	84*
Birth weight	0.78	19	0.77	85

* Birth height data is missing for one pair

Table 3 illustrates height and weight at birth and at 18 years of age for the boys. Having excluded the girls, both height and weight at birth are a little higher ie. around 48 cm and 2.7 kg respectively. Especially for the MZ twins there is a trend for boys to show

higher birthheight and weight in comparison to the girls (Table 1). Average birthweight for the MZ twins is 2.77 kg and for the DZ twins 2.68 kg. Average height and weight for MZ twin boys at 18 years of age is 180 cm and 66.1 kg respectively. Comparable data for the DZ twins is 178.4 cm and 62.8 kg. The differences between MZ and DZ boys in height and weight at birth and at 18 years of age are not significant.

Table 3 - Height (cm) and weight (kg) at birth and at 18 years of age for male MZ and DZ twins

	MZ			DZ			t
	X	S	N	X	S	N	
Birth height	48.10	2.66	18	47.71	3.07	44	0.50
Height at 18 yr	180.00	3.65	18	178.39	5.82	44	1.31
Birth weight	2.77	0.54	18	2.68	0.56	44	0.59
Weight at 18 yr	66.10	10.00	18	62.77	6.30	44	1.31

Within-pair correlations for height and weight at birth for MZ boys (0.91 and 0.89) are considerably higher than for DZ boys (0.74 and 0.59) (Table 4). This is in contrast to the situation for the whole group at birth where MZ and DZ correlations were of the same magnitude (Table 2). Both height and weight correlations are higher for MZ boys than for MZ girls at birth while the opposite is true for DZ pairs. It has to be taken into consideration, however, that the number of pairs is rather small. At 18 years the MZ twin boys are very similar for both height (0.84) and weight (0.92), while the DZ twin boys show only moderate similarity in height (0.47) and weight (0.60) at this age.

Table 4 - Within-pair correlations for height and weight at birth and at 18 years of age

	MZ		DZ	
	r	No. pairs	r	No. pairs
Birth height	0.91	9	0.74	22
Height at 18 yr	0.84	9	0.47	22
Birth weight	0.89	9	0.59	22
Weight at 18 yr	0.92	9	0.60	22

II. Comparisons of mental growth in MZ and DZ twins

In grades 6 and 9, when the twins were 13 and 16 years old, average marks in theoretical subjects, as well as marks in physical education, were collected and are illustrated in Table 5. The DZ twins have somewhat higher marks than the MZ twins in both theoretical

subjects and physical education. However, the difference is not significant in grade 6, but in grade 9 the DZ twins have significantly higher grades than MZ twins both in physical education and in theoretical subjects.

Table 5 - Average marks in theoretical subjects and marks in physical education for MZ and DZ twins

	MZ			DZ			t
	X	S	N	X	S	N	
Grade 6 (13 yr)							
Average marks							
Theoretical subjects	3.13	0.73	56	3.23	0.67	190	1.00
Physical education	3.33	0.69	56	3.49	0.88	186	1.45
Grade 9 (16 yr)							
Average marks							
Theoretical subjects	2.95	0.87	56	3.27	0.71	172	2.62**
Physical education	2.96	0.98	50	3.40	1.06	160	2.73**

** p<0.01

In Table 6 within-pair correlations are given for the two groups in both grades. The MZ twins correlations are very high for average marks in theoretical subjects and marks in physical education (approx. 0.95 and 0.85) in both grade 6 and 9. The correlations are very low for marks in physical education in both grades (around 0.25). for the DZ twins. For theoretical subjects however the DZ twins correlations are higher but tend to decrease a little from grade 6 to 9 (0.48 and 0.41 respectively).

Table 6 - Within-pair correlations for marks in theoretical subjects and physical education for MZ and DZ twins

	MZ		DZ	
	r	No. pairs	r	No. pairs
Grade 6 (13 yr)				
Average marks				
Theoretical subjects	0.94	28	0.48	95
Physical education	0.85	28	0.22	93
Grade 9 (16 yr)				
Average marks				
Theoretical subjects	0.95	25	0.41	86
Physical education	0.84	25	0.25	80

Table 7 illustrates the average results in ability tests for the male twins at 13 and 18 years. MZ and DZ twins seem to have fairly similar results at 13 years of age. At 18 however the MZ twins have significantly higher average scores than the DZ twins in verbal and technical tests.

Table 7 - Ability test scores for MZ and DZ male twins at 13 and 18 years of age

	MZ			DZ			t
	X	S	N	X	S	N	
13 years of age							
Verbal test	5.44	1.87	16	5.30	1.64	46	0.26
Spatial test	5.31	1.69	16	5.61	1.71	46	1.11
Numerical test	5.63	2.09	16	5.26	2.05	46	1.22
18 years of age							
Verbal test	5.88	1.32	16	4.98	1.73	46	2.58*
Spatial test	5.81	1.51	16	5.72	1.61	46	0.65
Technical test	6.08	1.60	16	4.96	1.78	46	3.20**

* $p < 0.05$ ** $p < 0.01$

Table 8 illustrates within-pair correlations for the boys in the mental ability tests at 13 and 18 years of age. The ability tests at 13 years old (grade 6) are not exactly the same as those on entering military service at 18 years. The verbal and spatial tests do, however, measure the same factor at both intervals. Within-pair correlations are fairly high for MZ boys in the verbal and numerical tests at 13 (0.70 and 0.80). While in the spatial test there is a moderate correlation (0.58). It has to be considered, however, that these correlations are based on 8 twin pairs only. The DZ pairs at age 13 show moderate

Table 8 - Within-pair correlations in ability tests for MZ and DZ male twins at 13 and 18 years of age

	MZ		DZ	
	r	No. pairs	r	No. pairs
13 years of age				
Verbal test	0.70	8	0.45	23
Spatial test	0.58	8	0.32	23
Numerical test	0.80	8	0.51	23
18 years of age				
Verbal test	0.74	8	0.36	23
Spatial test	0.11	8	0.26	23
Technical test	0.84	8	0.10	23

correlations in the verbal and numerical tests (0.45 and 0.51) and a fairly low correlation in the spatial test (0.32). Correlations are of about the same magnitude at 18 years of age for MZ boys except for the spatial test (0.11). The correlations tend to increase for MZ boys except for the spatial test, while for DZ boys they tend to decrease with age in all three tests.

III. Comparisons of physical and mental growth for MZ and DZ twins related to low birthweight and other birth complications

Table 9 shows the comparison of within-pair correlations in test results at 13 years of age for twin pairs with low birthweights (< 2.5 kg) and those with normal birthweights (≥ 2.5 kg). It indicates that the correlations in all tests are higher for low birthweight MZ twins compared to normal birthweight MZ twins. For DZ twins the opposite is true. Normal weight DZ twins show higher correlations than low birthweight pairs. For the latter negative correlations are found.

Table 9 - Within-pair correlations at 13 years of age in ability test results for MZ and DZ twins in relation to birthweight

	MZ				DZ			
	<2.5 kg		≥2.5 kg		<2.5 kg		≥2.5 kg	
	r	No. pairs	r	No. pairs	r	No. pairs	r	No. pairs
Verbal	0.82	5	0.75	8	0.28	19	0.62	32
Spatial	0.78	5	0.69	8	-0.21	19	0.19	32
Numerical	0.88	5	0.74	8	-0.23	19	0.39	32

A comparison of within-pair correlations for marks shows a decrease from grade 6 to grade 9 for the low birthweight twins but not for the normal weight twins. This is true for both MZ and DZ pairs. It must be considered however, that these analyses are based on few twin pairs (Table 10).

In recent years, multiple births have become more safe thanks to modern antenatal diagnosis and better technical equipment. At the outset of this study (1953) twin births undoubtedly were more risky and complicated. Studies at that time related how breech delivery, forceps delivery, foot presentation, vacuum extraction and cesarean section were common in twin deliveries. This study confirmed that both MZ and DZ twins are often born with different birth complications and it gives a within-pair correlation of 0.90 for MZ twins and 0.93 for DZ twins. The predominant problems are prematurity and intrauterine growth retardation.

Of 19 MZ pairs, both twins in 8 pairs were delivered in a complicated way. In one MZ twin pair only one infant had a complicated delivery. Looking at the 86 DZ pairs,

both twins in 29 of these had a complicated delivery. In two DZ pairs delivery was complicated for one of the infants only. Thus, it can be seen that birth complications are fairly common for twins and that MZ twins have a somewhat higher frequency of such complications.

Table 10 - Within-pair correlations for marks in theoretical subjects and physical education for MZ and DZ twins related to birthweight. Grades 6 and 9

	MZ				DZ			
	<2.5 kg		≥2.5 kg		<2.5 kg		≥2.5 kg	
	r	No. pairs	r	No. pairs	r	No. pairs	r	No. pairs
Grade 6								
Average marks								
Theoretical subjects	0.81	5	0.88	8	0.50	20	0.49	32
Physical educ.	0.87	5	0.86	9	0.48	20	-0.14	32
Grade 9								
Average marks								
Theoretical subjects	0.38	5	0.91	9	0.11	20	0.64	32
Physical educ.	0.67	5	0.83	9	0.08	17	0.23	31

DISCUSSION

This study shows that within-pair similarity in height and weight at birth is of the same magnitude for both MZ and DZ twins. This coincides with data reported by Scheinfeld [12] and Wilson [16].

A comparison was also made of height and weight similarity for MZ and DZ male twins at birth and also at 18 years of age. MZ male twins tend to be very similar in both height and weight at birth and at 18 years of age. This was also reported by Bergman [4]. DZ male twins, on the other hand, show a decrease in within-pair similarity for height at 18 years of age while their weight correlations are of approximately the same magnitude. Fischbein [7] and Bergman [4] reported large differences in these correlations for male and female twins with much greater decrease in weight correlations for female DZ twins than for males at adult age.

MZ twins seem to obtain somewhat lower marks than DZ twins in both theoretical subjects and physical education, and this difference tends to increase from 13 to 16 years of age. Fischbein [8] in a Swedish longitudinal twin project reported a similar trend, particularly for the MZ girls to get lower grades than the DZ girls. Within-pair correlations for marks in theoretical subjects show a slightly divergent trend, in that the MZ twins tend to be very similar at both 13 and 16 years of age while similarity in the DZ twins

tended to decrease with age. This same trend has been reported by Fischbein [8] as regards achievement test results and so could be interpreted as an interactional effect with MZ twins reacting similarly to school influences and DZ twins reacting differently. In physical education the MZ twins also seem to be very similar while there is a low within-pair similarity for the DZ twins at both 13 and 16 years of age.

In the ability test results for the male twins at 13 and 18 years of age, the MZ twins tend to have somewhat higher average scores than the DZ twins, particularly at 18. This too is in accordance with previous findings, ie. that MZ females but not males are at a disadvantage concerning school achievement and ability test results [8]. The within-pair correlations in ability test results for male MZ and DZ twins at 13 and 18 show a divergent trend in both the verbal and numerical-technical test. This also was reported by Fischbein, particularly for verbal test results [8]. This may indicate that this type of ability is influenced by hereditary factors interacting with environmental influences, thus making the MZ twins more similar and the DZ twins less similar over time.

For the spatial test the within-pair correlations are very low for both MZ and DZ twins, particularly at 18 years of age. This might be an effect of random influences. It must be remembered that these correlations are based on few twin pairs.

Birth complications and low birthweight affect the mental development in DZ pairs differently than in MZ pairs. Both the MZ and DZ low birthweight twins tended to show decreasing within-pair correlations over time which points to the importance of prenatal environmental influences. This accords with an earlier study by Alin Åkerman [3]. Intrauterine environmental factors are very important for the future development [1] and an interactional trend can be seen already at birth. Thus, a great deal can be learned by using the twin study method in relation to hereditary and environmental influences. Another important factor is that birth status as well as birthweight or birth complications, with few exceptions, fails to be analysed in other studies — yet these factors seem to be important for the development of infants. We can therefore conclude that interactional effects can already prenatally influence the development of twins. This means therefore that the same environment can have a different influence on MZ and DZ twins already at birth.

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