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Inbreeding Depression in Anthropometric Traits Among Telaga Boys of Kharagpur, West Bengal, India

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A B S T R A C T

Inbreeding depression in phenotypic variations as well as reproductive capacity was reported in animals. Depression of physical measurements in human beings especially among infants and adults due to inbreeding has also been reported all over the world. The present study is an attempt to examine the nature of inbreeding effect on growing children at each yearly age with increase of inbreeding intensity in a local endogamous population based on pedigree data. In general, mean values of measurements appear to be smaller in higher levels of inbreeding from that of lower levels of inbreeding in each yearly age. These differences are even more marked when grouped as low and high inbreeding level. The percent of inbreeding depression tends to be larger in post adolescent boys than in younger children.

Key words: *inbreeding depression, endogamous population, physical measurements, Kharagpur, India*

Introduction

Animal breeders who did not have a clear idea of genetic effects of inbreeding developed the concept of Inbreeding depression. The basic model of genetical analysis are concerned with change of means on inbreeding[1]. Significant depression of particular traits has been obtained in Japanese children and adults[2–10]; Hutterites of USA[11–13]; records of Italian conscripts[14]; Egyptian Nubians[15]; Brazilian immigrants[16–17]; French children[18]. Some studies on Croatian Island isolates have also revealed higher incidence of renal stones and cancer in inbred persons[19–20]. But there were indeed a number of exceptions. Besides, inbreeding depression in man is examined for characters, which are related with social and geographical categories affecting the rate of inbreeding. Some studies have corrected the results for a series of associated factors using multiple regression analysis. Even then, some authors have expressed a lingering doubt that the observed depressions are still influenced by environmental factors[21–22].

Indian studies have considerably removed this doubt about environmental rather than genetical significance of inbreeding effects in man by studying the effects on dermatoglyphic traits, and by measuring inbred and non inbred individuals from the same kindred groups who are matched for income and property[23–24]. Pedigree analyses and use of adequate samples from different degrees of inbreeding have displayed unequivocal reduction of means on inbreeding among endogamous populations e.g. Gampasati Kamma, Telaga, Pakonati Reddy populations of Andhra Pradesh, Sheikh Muslims of West Bengal, Quereshi Muslims of Uttar Pradesh and others[25–29].

The objective of the present study is to examine the effects of inbreeding on growing boys at each yearly age from 5 to 20 years with increase of inbreeding intensity in a local endogamous population, the Telaga of Kharagpur, West Bengal, India.

Materials and Methods

The Telaga population of Kharagpur, West Bengal (Figure 1) is a Telugu-speaking migrant population since late 1880s. The ancestors of the population came to Kharagpur town from Srikakulum, Vishakhapatnam and East Godavari districts of Andhra Pradesh to lay the railway lines of Bengal Nagpur railways. Since then they have been working in the railways. A great majority of the said populations is the outcome of kin-based migration. A large number of marriages among them

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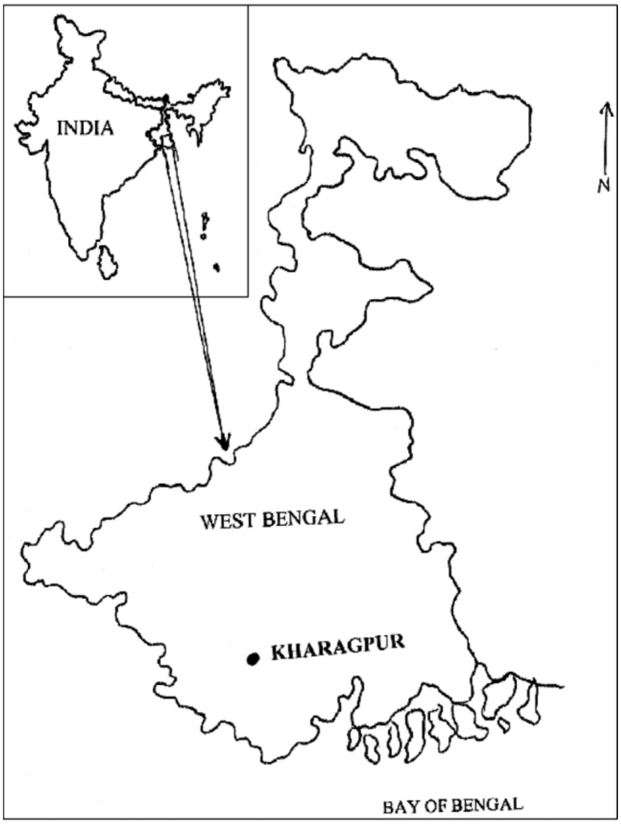

Fig. 1. Location of study area.

have taken place in the Kharagpur town itself, although only a few among them have retained their kinship links with their ancestral homes. Extensive pedigrees of at least five generations have been constructed from families having at least one growing child. Altogether 807 couples and their offspring form the local endogamous population[30]. The people live in the same type of railway quarters, and eat the same type of food. The inbred and non-inbred subjects were selected on the basis of pedigrees and children aged five to twenty years were measured. Preference was given to cousins belonging to the same kindred so that environmental variation was minimized for the present study. The results of study on the boys only are presented in the paper.

It was verified that consanguineous marriages were a tradition in Telugu speaking populations[31] and no consideration of attractiveness was made for contracting marriage in the Telaga population.

To measure the intensity, inbreeding coefficient (F) has been calculated for autosomal genes by applying Wright's path coefficient method utilizing F values of common ancestors of both parents. The boys were then classified into the (i) the offspring of unrelated parents (F=0.00), (ii) offspring of relatives more remote than first cousins (0.00<F<0.0625), (iii) offspring of first cousins (0.0625≤F<0.1250), and (iv) offspring of maternal uncle: niece pairs (F≥0.1250). Finally, for increase of sample size in each age, the subjects were divided into the low and high inbreeding levels, the former below F=0.625, and the latter with F≥0.625.

Measurements were taken on the basis of consent of the subjects aged five to twenty years in each case. Anthropometric measurements were taken upto the nearest 1.00 mm using standard techniques[32]. The subjects were requested to remove their shoes and put on light clothes during taking measurements. The mean values of stature (ST), sitting height (SH), bi-acromial diameter (BAD), and bi-illiac diameter (BID) in mm were calculated for each category of inbreeding.

Age estimation of all individuals have been aided by usual genealogical checks, reference to the important events, horoscopes where available, and birth or school certificates.

Results and Discussion

*Reduction of means of physical measurements with inbreeding in yearly age groups***:** The mean values of each of the physical measurements studied generally appear to be smaller in higher levels of inbreeding (as measured by F) than in lower levels of inbreeding in each year of age in boys (Tables 1–4). It is noteworthy that the exceptions to this general rule of »inbreeding depression« are rather very few despite the small size of sample for each yearly age group in a cross-sectional data. For example, there are only a few cases of exceptions for ST, SH, BAD, BID. This strengthen the hypothesis of lowering of means for physical measurements in each age in years with increase of inbreeding which would indicate recessive effects of involved genes for the traits under considerations.

It is also observed that the frequency of exceptions to the rule of »inbreeding depreciation« (reduction of mean) is greater in the lower degrees of inbreeding than in higher degrees.

The amount of percent inbreeding depressions also tend to be generally greater in older (post adolescent boys) than in younger boys for most of the measurements with a few exceptions especially for BAD, BID (Tables 1–4).

In low and high inbreeding: To eliminate disturbance due to small sample fluctuation and / or the possible non-linear effect on the inbreeding depression, the mean values are again compared between low (F=0.000 and F<0.0625) and high (F≥0.0625) levels of inbreeding. It is observed that the mean values of each of the physical measurements studied are smaller in high level of inbreeding in all ages of Telaga boys (Tables 5–8). The reduction of means is statistically significant in some cases.

*Younger and older age groups***:** It is observed that for most of the measurements, there is no exception to the general rule of reduction of means with inbreeding in higher age groups in boys. This agrees with earlier observations[17,23,33] that inbreeding depression tends to increase with age especially after puberty and that heritability increases with age during growing period[34].

TABLE 1
MEAN (X) AND DEPRESSION PERCENTAGE (d) OF STATURE IN TELAGA BOYS OF DIFFERENT LEVELS OF INBREEDING IN COMPARISON WITH NON-INBRED BOYS

Age in years	F=0.000		0.000<F<0.0625			0.0625≤F<0.1250			F≥0.1250		
	N	X (mm)	N	X (mm)	d (%)	N	X (mm)	d (%)	N	X (mm)	d (%)
5	15	1055.00	5	1037.40	1.67	6	1017.83	3.52	9	1013.89	3.90
6	16	1076.25	7	*1082.43	–	7	1076.14	0.10	8	1073.87	0.11
7	12	1156.92	6	1140.17	1.45	10	1114.40	3.67	9	1112.00	3.88
8	18	1211.44	8	1206.62	0.40	12	1203.67	0.64	13	1199.85	0.96
9	21	1231.05	5	1226.00	0.41	8	1224.87	0.50	13	1218.92	0.98
10	17	1301.71	6	1298.17	0.27	7	1288.71	1.40	13	1276.31	2.35
11	19	1374.37	7	1365.00	0.68	6	1351.33	1.68	10	1341.00	2.43
12	20	1445.80	6	1455.00	–	6	1443.50	0.16	10	1436.20	0.66
13	15	1483.80	7	1482.57	0.08	9	1480.44	0.23	11	1464.54	1.30
14	20	1549.25	6	*1566.50	–	7	*1560.73	–	10	1547.90	0.80
15	15	1608.53	6	1582.67	1.61	8	1576.37	2.00	10	1562.70	2.85
16	16	1625.19	7	1604.00	1.30	7	1601.86	1.44	10	1595.90	1.80
17	15	1647.33	5	1614.20	2.01	7	1605.57	2.54	10	1603.60	2.65
18	13	1656.69	6	1622.33	2.07	8	1611.12	2.75	10	1610.80	2.77
19	11	1668.36	6	1627.83	2.43	6	1615.33	3.18	8	1615.37	3.18
20	10	1678.00	5	1641.00	2.21	6	1633.17	2.67	8	1628.00	2.98

*increased mean from only F=0.00

TABLE 2
MEAN (X) AND DEPRESSION PERCENTAGE (d) OF SITTING HEIGHT IN TELAGA BOYS OF DIFFERENT LEVELS OF INBREEDING IN COMPARISON WITH NON-INBRED BOYS

Age in years	F=0.000		0.000<F<0.0625			0.0625≤F<0.1250			F≥0.1250		
	N	X (mm)	N	X (mm)	d (%)	N	X (mm)	d (%)	N	X (mm)	d (%)
5	15	549.80	5	546.20	0.65	6	536.17	2.48	9	534.89	2.71
6	16	556.00	7	552.71	0.59	7	550.14	1.05	8	547.75	1.48
7	12	605.92	6	580.50	4.19	10	565.90	6.60	9	563.78	6.95
8	18	633.06	8	621.25	1.87	12	619.67	2.11	13	606.85	4.14
9	21	636.33	5	630.20	0.96	8	+630.50	0.92	13	624.77	1.82
10	17	654.53	6	643.33	1.71	7	641.57	1.98	13	641.46	2.00
11	19	669.74	7	666.14	0.54	6	660.67	1.35	10	658.10	1.74
12	20	713.15	6	*717.67	–	6	710.33	0.39	10	709.20	0.55
13	15	745.20	7	741.71	0.47	9	738.78	0.86	11	730.81	1.93
14	20	776.15	6	*779.33	–	7	772.43	0.48	10	770.50	0.73
15	15	806.87	6	796.33	1.31	8	791.62	1.89	10	778.00	3.58
16	16	823.62	7	810.43	1.60	7	805.29	2.23	10	802.10	2.61
17	15	834.87	5	828.00	0.82	7	811.29	2.82	10	809.10	3.09
18	13	841.00	6	833.83	0.85	8	818.87	2.63	10	816.10	2.96
19	11	847.00	6	837.50	1.12	6	829.33	2.09	8	821.12	3.06
20	10	853.10	5	840.20	1.51	6	832.33	2.43	8	826.00	3.18

*increased mean from only F=0.00, +increased mean from next lower class of F

It may be suggested on this basis that variation in the pattern of growth before adolescence may overwhelm the inbreeding effect on the change of mean measurements.

The inbreeding effect on the reduction of mean values appears to be significant by one-tailed t-test in some age groups for all physical traits. It is noteworthy that for the first two traits the significant reductions are more consistent in older (post adolescent) yearly age groups than in the youn2wger ages (Tables 5–8). This would strengthen the observation of greater inbreeding depression in post adolescent period than in earlier age groups for those traits. For BAD, BID measurements, however, significant reduction of means is observed only in younger age groups below 10 or 12 years in boys.

TABLE 3
MEAN (X) AND DEPRESSION PERCENTAGE (d) OF BI-ACROMIAL DIAMETER IN TELAGA BOYS OF DIFFERENT LEVELS OF INBREEDING IN COMPARISON WITH NON-INBRED BOYS

Age in years	F=0.000		0.000<F<0.0625			0.0625≤F<0.1250			F≥0.1250		
	N	X (mm)	N	X (mm)	d (%)	N	X (mm)	d (%)	N	X (mm)	d (%)
5	15	215.60	5	211.40	1.95	6	202.67	6.00	9	197.78	8.27
6	16	220.31	7	*222.14	–	7	215.00	2.41	8	205.75	6.61
7	12	230.17	6	*235.17	–	10	226.80	1.46	9	222.78	3.21
8	18	254.67	8	249.50	2.03	2	+251.50	1.24	13	245.54	3.59
9	21	256.90	5	254.60	0.90	8	+255.37	0.60	13	249.23	2.99
10	17	278.59	6	268.33	3.68	7	267.71	3.91	13	260.54	6.48
11	19	287.21	7	278.57	3.01	6	280.67	2.28	10	275.60	4.04
12	20	304.00	6	301.83	0.71	6	297.33	2.19	10	293.71	3.38
13	15	317.73	7	311.00	2.12	9	308.11	3.03	11	301.45	5.12
14	20	331.95	6	326.50	1.64	7	323.14	2.65	10	318.3	4.11
15	15	343.27	6	340.33	0.86	8	337.75	1.61	10	327.00	4.74
16	16	350.19	7	346.43	1.07	7	341.14	2.58	10	337.70	3.57
17	15	356.40	5	352.60	1.07	7	349.00	2.08	10	343.80	3.54
18	13	360.46	6	356.83	1.01	8	354.37	1.69	10	348.50	3.32
19	11	365.27	6	362.00	0.90	6	359.00	1.72	8	352.37	3.53
20	10	368.40	5	365.40	0.81	6	361.17	1.96	8	356.50	3.23

*increased mean from only F=0.00, +increased mean from next lower class of F

TABLE 4
MEAN (M) AND DEPRESSION PERCENTAGE (d) OF BI-ILIAC IN TELAGA BOYS OF DIFFERENT LEVELS OF INBREEDING IN COMPARISON WITH NON-INBRED BOYS

Age in years	F=0.000		0.000<F<0.0625			0.0625≤F<0.1250			F=0.1250		
	N	X (mm)	N	X (mm)	d (%)	N	X (mm)	d (%)	N	X (mm)	d (%)
5	15	159.13	5	*153.00	3.85	6	150.00	5.74	9	+151.89	4.55
6	16	165.31	7	159.57	3.47	7	157.71	5.60	8	155.00	6.24
7	12	171.83	6	167.50	2.52	10	163.00	5.14	9	160.78	6.43
8	18	179.00	8	176.62	1.33	12	172.17	3.82	13	+172.23	3.78
9	21	186.52	5	183.40	1.67	8	177.00	5.10	13	175.54	5.89
10	17	194.41	6	190.17	2.18	7	184.57	5.06	13	+186.08	4.28
11	19	203.00	7	196.00	3.45	6	189.50	6.65	10	189.00	6.90
12	20	209.15	6	202.17	3.34	6	199.33	4.70	10	199.30	4.71
13	15	218.06	7	209.57	3.89	9	+210.22	3.60	11	209.36	3.99
14	20	228.10	6	220.33	3.41	7	218.43	4.24	10	216.40	5.13
15	15	231.87	6	227.00	2.10	8	224.75	3.07	10	222.10	4.21
16	16	236.12	7	233.71	1.02	7	231.43	1.99	10	227.40	3.69
17	15	239.07	5	236.8	0.95	7	234.14	2.06	10	232.20	2.87
18	13	241.08	6	239.17	0.79	8	238.62	1.02	10	236.60	1.86
19	11	243.18	6	241.33	0.76	6	240.17	1.24	8	239.12	1.67
20	10	245.60	5	243.00	1.06	6	+243.50	0.86	8	241.12	1.82

*increased mean from only F=0.00, +increased mean from next lower class of F

Conclusion

Change of means in each yearly age group: Mean values of all the physical measurements tend to decline with inbreeding even in rather small samples in each yearly age group from 5 to 20 years, except for a few cases of small sampling fluctuations. The reduction of means with inbreeding is found to be significant at 5% level of probability in even small samples in each yearly age-group more often in boys and in older age group than in younger.

In high and low inbreeding: Besides, sampling fluctuations, causing exceptions to the rule of 'inbreeding

TABLE 5
MEAN (X) STATURE OF TELAGA BOYS OF YEARLY AGE GROUPS FROM 5 TO 20 YEARS IN HIGH (F≥0.0625) AND LOW (0.00≤F<0.0625) DEGREES OF INBREEDING

Age in years	0.00≤F<0.0625			F≥ 0.0625			Significant t
	N	X (mm)	SE	N	X (mm)	SE	
5	20	1050.60	4.00	15	1015.47	5.18	5.37****
6	23	1078.13	7.08	15	1074.93	9.53	
7	18	1151.34	7.47	19	1113.26	10.10	3.03***
8	26	1209.96	7.67	25	1201.68	11.54	
9	26	1230.08	8.22	21	1221.19	10.84	
10	23	1300.78	6.66	20	1280.65	10.59	
11	26	1371.85	9.11	16	1344.87	11.88	
12	26	1447.92	9.72	16	1438.94	17.31	
13	22	1483.41	8.20	20	1471.70	12.45	
14	26	1553.23	7.72	17	1553.18	13.33	
15	21	1601.14	8.51	18	1568.78	10.81	2.35*
16	23	1618.74	7.70	17	1598.35	11.03	
17	20	1639.05	8.38	17	1604.41	10.72	2.55**
18	19	1645.84	6.90	18	1610.94	10.80	2.72***
19	17	1654.06	10.18	14	1615.35	16.00	2.01*
20	15	1665.67	9.08	14	1630.22	12.65	2.28*

****p<0.001, ***p<0.01, **p<0.02, *p<0.05

TABLE 6
MEAN (X) SITTING HEIGHT OF TELAGA BOYS OF YEARLY AGE GROUPS FROM 5 TO 20 YEARS IN HIGH (F≥0.0625) AND LOW (0.00≤F<0.0625) DEGREES OF INBREEDING

Age in years	0.00≤F<0.0625			F≥0.0625			Significant t
	N	X (mm)	SE	N	X (mm)	SE	
5	20	548.90	2.77	15	535.40	4.93	2.38*
6	23	555.00	3.48	15	548.86	6.06	3.91****
7	18	597.45	5.59	19	564.90	6.17	
8	26	629.43	5.43	25	613.00	6.26	
9	26	635.15	4.95	21	626.95	7.57	
10	23	651.61	4.58	20	641.50	7.13	
11	26	668.77	6.43	16	659.06	5.96	
12	26	714.19	5.58	16	709.62	10.27	
13	22	744.09	4.73	20	734.40	8.83	
14	26	776.88	4.38	17	771.29	9.05	
15	21	803.86	4.97	18	784.05	7.72	2.16*
16	23	819.61	5.31	17	803.41	7.71	
17	20	833.15	4.34	17	810.00	6.97	2.82***
18	19	838.74	4.60	18	817.33	6.95	2.57**
19	17	843.65	4.06	14	824.64	8.51	2.04*
20	15	848.80	3.82	14	828.71	7.29	2.44**

****p<0.001, ***p<0.01, **p<0.02, *p<0.05

TABLE 7
MEAN (X) BI ACROMIAL DIAMETER OF TELAGA BOYS OF YEARLY AGE GROUPS FROM 5 TO 20 YEARS IN HIGH (F≥0.0625) AND LOW (0.00≤F<0.0625) DEGREES OF INBREEDING

Age in years	0.00≤F<0.0625			F≥0.0625			Significant t
	N	X (mm)	SE	N	X (mm)	SE	
5	20	214.55	1.71	15	199.74	3.23	4.05****
6	23	220.87	2.25	15	210.07	4.09	2.31*
7	18	231.84	2.05	19	224.90	3.32	
8	26	253.08	1.93	25	248.40	4.36	
9	26	256.46	2.81	21	251.57	3.84	
10	23	275.91	2.53	20	263.05	4.91	2.33*
11	26	284.88	4.22	16	277.50	5.00	
12	26	303.50	3.00	16	295.07	7.16	
13	22	315.59	3.09	20	304.44	4.81	
14	26	330.69	2.73	17	320.29	5.60	
15	21	342.43	2.88	18	331.78	6.04	
16	23	349.05	3.32	17	339.12	5.56	
17	20	355.45	2.90	17	345.94	4.03	
18	19	359.31	3.62	18	351.11	4.87	
19	17	364.12	2.54	14	355.21	5.21	
20	15	367.40	3.60	14	358.50	5.11	

****p<0.001, *p<0.05

TABLE 8
MEAN (X) BI-ILIAC DIAMETER OF TELAGA BOYS OF YEARLY AGE GROUPS FROM 5 TO 20 YEARS IN HIGH (≥0.0625) AND LOW (0.00≤F<0.0625) DEGREES OF INBREEDING

Age in years	0.00≤F<0.0625			F≥0.0625			Significant t
	N	X (mm)	SE	N	X (mm)	SE	
5	20	157.60	1.54	15	151.33	1.20	3.21***
6	23	163.57	1.27	15	156.27	1.37	3.91****
7	18	170.39	2.94	19	161.95	3.48	
8	26	178.27	2.96	25	172.20	3.81	
9	26	185.92	2.64	21	176.10	3.86	2.10*
10	23	193.30	2.18	20	185.55	4.28	
11	26	201.12	2.77	16	189.19	4.75	2.17*
12	26	207.54	3.02	16	199.31	5.80	
13	22	215.36	3.89	20	209.75	4.66	
14	26	226.31	3.31	17	217.24	5.32	
15	21	230.48	3.25	18	223.28	6.71	
16	23	235.39	3.11	17	229.06	6.60	
17	20	238.50	3.82	17	233.00	5.35	
18	19	240.47	3.69	18	237.50	4.98	
19	17	242.53	3.50	14	239.57	6.37	
20	15	244.73	4.29	14	242.14	6.88	

****p<0.001, ***p<0.01, *p<0.05

depression' occur more often in the lower degrees of recognized inbreeding (0.00<F<0.0625) than in higher degrees of inbreeding, In fact, such exceptions to the rule of mean reduction with inbreeding not observed when all individuals with low inbreeding (0.00<F<0.0625) are compared with those with high inbreeding (F≥0.0625) in each age group.

Change of means in younger and older children: The amount of percent inbreeding depression tends to be larger in post adolescent boys than in younger children for ST, SH with a few exceptions especially for BAD, BID measurements. Furthermore, there is no apparent exceptions to the rule of reduction of mean with inbreeding in higher age groups except in some cases for BAD, BID measurements. This may be related to the fact that environmental variations in the rate of growth before adolescence might over whelm the inbreeding effect on change of means before adolescence.

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SMANJENJE TJELESNIH DIMENZIJA USLIJED SROĐIVANJA U TELAGA DJEČAKA IZ KHARAGPURA, ZAPADNI BENGAL, INDIJA

SAŽETAK

Smanjenje fenotipske varijabilnosti kao i reproduktivnog kapaciteta uzrokovano srođivanjem (»inbreeding depression«) dobro je poznat fenomen u životinjskom svijetu. Smanjenje antropometrijskih dimenzija uslijed srođivanja, posebno u novorođenčadi i odraslih ljudi, također je poznata činjenica dokumentirana širom svijeta. Cilj ovog rada bio je ispitati učinke srođivanja na temelju rodoslovlja na rast i razvoj djece. Istraživanje je provedeno u lokalnoj endogamnoj populaciji Telaga (Zapadni Bengal, Indija), a djeca (dječaci) su izabrana tako da za svaku dob reprezentiraju i obitelji karakterizirane različitim stupnjem srođenosti. Prosječne vrijednosti mjerenih varijabli u svakoj pojedinoj dobi su pokazivale manje vrijednosti pri višim stupnjevima srođenosti. Te su razlike bile još istaknutije kada su uspoređene skupine niskog i visokog stupnja srođenosti. Učinak depresije srođivanjem (»inbreeding depression«) izraženiji je u postadolescentnih dječaka nego kod mlađe djece.