Coll. Antropol. 30 (2006) 2: 291–296
Original scientific paper

Parent-Child Correlation for Various Indices of Adiposity in an Endogamous Indian Population

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A B S T R A C T

The study was conducted on 1,042 Punjabi adults and adolescent boys and girls (11–17 years) belonging to middle class families residing in Delhi, India. To study the relative influence of genetic and environmental factors on various fat measures, a set of 7 body measurements namely weight, stature and skinfold thickness at biceps, triceps, subscapular, suprailiac and medial calf measurements was taken on each subject. There was a redistribution of fat away from extremity towards the trunk, a rapid occurring process in males than in females. Increase in body mass index (BMI) with age was more pronounced in females than in males, both at adolescence and adult stage. There was an increase in grand mean thickness (GMT) calculated as mean of all five skinfold thicknesses, in adolescent girls where as in adolescent boys it fluctuated with age. The trunk/extremity ratios reflected a trend in favor of increase in trunk fat, more marked in boys than in girls. The correlations were of low magnitude, however, some skin folds displayed relatively higher value of correlation indicating that these could be determinant of adult obesity.

***Key words**: adolescents, parents, fat measures, correlations, family study*

Introduction

Anthropometric measurements are the simplest, non-invasive and most convenient tool for the assessment of growth and development[1], for gender differences and rural-urban influences[2], to assess structural adaptation to high altitude[3] etc. Evaluation of parent-child correlation based on 'family studies', is an ideal technique to understand the genetic and environmental effects on biological aspects of human beings.

More than six decades has contributed to studies on parent- child correlation for stature and other body measurements[4–12]. Ethnically and environmentally different populations covering wide age range constituted these studies. One of the greatest advantages of measurement of parents and their children is that the comparison of body parameters easily reveals the presence of secular trend[13,14]. Individual and population differences have mostly been studied using the basic morphological (anthropometric) growth measures such as stature and body mass[15].

Family variables appear to be the most important correlates of obesity. The risk of obesity among children increases in proportion to parental obesity. It is lowest when neither is obese, higher when one and highest when both the parents are obese. Although these data suggests a genetic basis, similarity of process of biologic parent-child progenies and those in adoptive combinations emphasize the importance of environmental influences. Correlation among biological siblings does not differ from those genetically unrelated siblings in families with adopted children. Finally, genetic factors do not explain correlates between spouses.

The final size and shape attained by the growing child are determined as a result of continuous interaction between genetic and environmental factors overtime. The role played by the environment becomes important after birth because then the child is exposed to a variety of new environmental factors. The child's ability to cope with these factors will determine the differences in adult physique. Hartz et al.[16] in heritability studies investigated the relative importance of heredity and environment on the expression of given trait.

Commonly the results of heritability study are interpreted as the extent to which a given trait can be influenced by environment. For obesity, however, this interpretation is misleading, whatever the heritability found for obesity the potential for environmental influence is

Received for publication August 28, 2005

great. Family environment accounted for 32% of variation in obesity if all children were used. Family environment which consists of such things as parental care and child rearing techniques has an important effect on childhood obesity. But it is not easy to separate the effect of genetic factors from environmental. The degree of resemblance varies with character, some showing more some less[17]. The variability of the morphometric traits in a population has an influence on the values of correlation between relatives. Presently studies on the parent- child correlations are the most widely used heritability estimate in growth and development.

Parent-Child pattern of subcutaneous fat distribution has not been extensively investigated. The present study was undertaken to report the parent-child correlations for stature, weight and adiposity measures in an endogamous Indian urban population.

Materials and Methods

One thousand and forty two Punjabi speaking Khatri adults and children of both sexes volunteered as subjects in the present study belonging to 108 middle class families residing in Delhi.Khatris practice gotra exogamy and caste endogamy. The children included adolescents at a yearly interval from age 11 through 17 years, mothers were of the age 32–50 years and fathers were 35–55 years of age.

A set of seven measurements inclusive of body weight using spring balance to the nearest 500 g, stature with the help of Martin's Anthropometer to the nearest mm. Skinfold thickness was recorded with Holtain's skinfold caliper which exerted a constant pressure of 10 g/mm^2 at the contact surface.The sites measured were biceps, triceps, subscapular, suprailiac and medial calf on all the subjects.

All the measurements were taken according to the techniques described by Weiner and Laurie[18]. Body mass index (BMI) and grand mean thickness (GMT) indicators of fatness, Trunk-Extremity ratio of subcutaneous fat -indicators of fat distribution pattern over the body were calculated for both parents and their adolescent children.

Statistical analysis

Using computer software SPSS, version 7.0, means and standard deviations and Parent-offspring correlation coefficients (Pearson correlation) were computed. As an indicator of fatness – body mass index was calculated as weight in kg divided by stature in meter square and the grand mean thickness (GMT) was calculated as mean of all five skinfold thicknesses. For evaluating the regional distribution of body fat, trunk/extremity ratio was calculated by dividing sum of subscapular + suprailiac skinfold thickness with triceps + medial calf skinfold thickness and the profile of fatness was depicted with the help of skinfold thickness rankings.

Results

The means and standard deviations of various measurements for parents and their children are given in Table 1 to 3. Table 4 gives the body mass index (BMI), grand

TABLE 1
ANTHROPOMETRIC VARIABLES AMONG FATHERS AND MOTHERS

Variable	Father n=108 (X±SD)	Mother n=108 (X±SD)
Weight (kg)	68.38±11.56	62.09±12.17
Stature (cm)	165.45±6.5	153.63±4.8
Biceps SF (mm)	7.25±3.04	11.13±5.51
Triceps SF(mm)	11.61±5.86	20.90±6.92
Subscapular SF (mm)	23.39±7.24	25.16±8.83
Suprailiac SF (mm)	28.09±16.54	24.87±8.81
Medial calf SF (mm)	12.80±8.55	21.75±8.59

SF – skinfold thickness

TABLE 2
ANTHROPOMETRIC VARIABLES AMONG ADOLESCENT BOYS

Variable	Age (years)						
	11 n=60 (X±SD)	12 n=61 (X±SD)	13 n=65 (X±SD)	14 n=61 (X±SD)	15 n=53 (X±SD)	16 n=60 (X±SD)	17 n=54 (X±SD)
Weight (kg)	34.53±7.93	37.13±7.89	41.94±9.38	45.19±9.27	51.97±10.28	55.39±8.83	56.19±9.92
Stature (cm)	140.32±7.1	144.90±8.1	151.91±8.1	153.90±2.2	164.08±7.6	167.88±5.8	168.11±6.5
Biceps SF (mm)	7.35±3.39	7.22±2.69	7.04±3.21	5.58±2.87	5.77±2.92	6.02±1.71	4.33±2.22
Triceps SF(mm)	12.02±3.85	11.71±4.99	11.47±4.11	9.05±4.80	9.29±4.68	9.73±4.17	7.51±4.57
Sub scapular SF (mm)	11.99±6.74	11.13±3.18	10.28±4.92	10.18± 6.99	11.84±6.59	17.24±8.93	11.04±7.64
Suprailiac SF (mm)	15.52±7.54	15.44±5.89	15.38±6.53	12.11±7.21	15.55±7.33	18.06±9.77	14.85±4.14
Medial Calf SF (mm)	13.19±6.96	14.34±6.43	14.44±6.92	11.84±7.20	11.92±6.82	12.37±8.09	9.35±7.38

SF – skinfold thickness

TABLE 3
ANTHROPOMETRIC VARIABLES AMONG ADOLESCENT GIRLS

Variable	Age (years)						
	11 n=54 (X±SD)	12 n=60 (X±SD)	13 n=60 (X±SD)	14 n=62 (X±SD)	15 n=51 (X±SD)	16 n=64 (X±SD)	17 n=61 (X±SD)
Weight (kg)	34.32±7.00	38.55±8.34	47.34±7.40	45.10±7.73	48.41±5.84	48.42±5.11	50.95±7.11
Stature (cm)	135.38±8.2	148.68±7.9	151.23±6.2	153.57±6.2	155.34±5.1	155.45±4.2	155.80±6.6
Biceps SF (mm)	7.33±3.39	8.42±2.69	7.20±3.71	7.57±2.87	8.29±2.92	8.31±1.71	8.38±2.22
Triceps SF (mm)	11.87±3.85	13.93±4.99	3.17±4.11	13.33±4.80	15.05±4.68	15.17±4.17	15.53±4.57
Subscapular SF (mm)	12.37±6.74	12.38±5.18	12.37±4.92	15.19±6.99	15.95±6.59	17.76±8.93	18.88±7.64
Suprailiac SF (mm)	14.58±7.54	14.64±5.89	14.26±6.53	15.94±7.21	16.44±7.33	20.58±9.79	26.79±4.14
Medial calf SF (mm)	15.48±6.96	16.87±6.43	14.53±6.92	16.49±7.20	18.00±6.82	19.50±8.09	21.40±7.38

SF – skinfold thickness

TABLE 4
BODY MASS INDEX, GMT AND TRUNK-EXTREMITY RATIO OF THE SUBJECTS IN DIFFERENT AGE GROUPS

Age (Years)	Boys			Girls		
	BMI	T/E Ratio	GMT	BMI	T/E Ratio	GMT
11	18.13	1.091	12.01	18.83	0.985	12.33
12	17.66	1.019	11.97	17.36	0.877	13.25
13	18.15	0.990	11.72	20.76	0.961	12.31
14	19.49	1.067	9.75	19.02	1.044	15.22
15	19.32	1.291	10.87	20.15	0.980	14.75
16	19.62	1.597	12.68	20.15	1.106	16.26
17	19.91	1.545	9.42	20.94	1.239	18.19
Fathers	21.44	2.109	16.62	–	–	–
Mothers	25.84	1.173	20.76	–	–	–

BMI – body mass index, GMT – grand mean thickness (mm), T/E Ratio – trunk/extremity ratio

mean thickness (GMT) and trunk-extremity ratio for parents and children. Father-daughter, mother-daughter, father-son and mother-son correlations for various anthropometric measurements are given in table 5, 6, 7 and 8 respectively.

Among the adult group, females were shorter, lighter but fatter than the males.The adolescent boys were leaner than the adolescent girls in all the age groups. The boys were taller than girls in the late adolescent years. During adolescent period, the boys lost fat despite an increase in weight but the girls continued to gain fat mass along with an increase in body weight. In both the sexes stature continued to increase from 11 to 17 years of age, so does the BMI.

It has been noticed that in few parent-child groups, some skinfold thicknesses displayed relatively higher value of correlation, biceps in father-13 year sons, in mother-14 years, 15 years and 17 years sons, mother-12 years daughter group, father-14years daughter group, triceps in father-14 years son group and in mother-11 and 17 years son group, subscapular in mother-17 years daughter group, mother-12 years, 16 years, 17 years son group, suprailiac in father-14 years sons group, mother-17 years sons group, and medial calf in mother-17 years daughters, 11 years and 14 years sons group.

Discussion

The biological development of human beings is due to the interaction of both genes and the environment. Genes are inherited and everything else is developed[19]. The study of human growth has been synonymous with measurements. Thus majority of traits in growth are quantitative traits. Fat is most readily influenced by environmental factors. Children tend to resemble their parents in stature, body proportions and rate of development[20].

The BMI is an index of overweight and a simultaneous increase in the GMT of skinfold thickness would entail this increase in weight due to increase in fatness. An increase in BMI with age in the present sample with a concurrent increase in the GMT is due to relative in-

TABLE 5
FATHER-DAUGHTER CORRELATIONS FOR VARIOUS ANTHROPOMETRIC VARIABLES IN DIFFERENT AGE GROUPS

Variable	Age (years)						
	11	12	13	14	15	16	17
Weight (kg)	0.133	0.109	0.030	0.301*	0.020	0.134	0.023
Stature (cm)	0.282*	0.054	0.103	0.087	0.192	0.004	0.197
Biceps SF (mm)	0.169	0.029	0.126	0.297*	0.205	0.073	0.118
Triceps SF (mm)	0.126	0.233	0.077	0.215	0.211	0.042	0.196
Subscapular SF (mm)	0.073	0.080	0.143	0.176	0.022	0.118	0.108
Suprailiac SF (mm)	0.143	0.173	0.106	0.156	0.158	0.076	0.123
Medial calf SF (mm)	0.123	0.033	0.084	0.014	0.034	0.031	0.185

*p< 0.05, SF – skinfold thickness

TABLE 6
MOTHER-DAUGHTER CORRELATIONS FOR VARIOUS ANTHROPOMETRIC VARIABLES IN DIFFERENT AGE GROUPS

Variable	Age (years)						
	11	12	13	14	15	16	17
Weight (kg)	0.005	0.094	0.136	0.084	0.067	0.097	0.196
Stature (cm)	0.001	0.033	0.131	0.018	0.097	0.165	0.132
Biceps SF (mm)	0.078	0.250*	0.211	0.120	0.167	0.116	0.036
Triceps SF (mm)	0.120	0.063	0.103	0.001	0.154	0.006	0.100
Subscapular SF (mm)	0.013	0.113	0.210	0.001	0.037	0.144	0.296*
Suprailiac SF (mm)	0.015	0.046	0.083	0.034	0.035	0.007	0.039
Medial calf SF (mm)	0.179	0.150	0.123	0.054	0.022	0.032	0.263*

*p< 0.05, SF – skinfold thickness

TABLE 7
FATHER-SON CORRELATIONS FOR VARIOUS ANTHROPOMETRIC VARIABLES IN DIFFERENT AGE GROUPS

Variable	Age (years)						
	11	12	13	14	15	16	17
Weight (kg)	0.046	0.061	0.049	0.230	0.150	0.071	0.156
Stature (cm)	0.084	0.062	0.135	0.039	0.021	0.192	0.121
Biceps SF (mm)	0.126	0.162	0.351**	0.172	0.232	0.062	0.047
Triceps SF (mm)	0.039	0.087	0.061	0.249*	0.159	0.030	0.037
Subscapular SF (mm)	0.063	0.039	0.025	0.047	0.007	0.127	0.051
Suprailiac SF (mm)	0.025	0.134	0.061	0.276*	0.088	0.084	0.087
Medial calf SF (mm)	0.032	0.221	0.068	0.039	0.009	0.135	0.029

*p< 0.05, **p< 0.05, SF – skinfold thickness

crease in fatness more pronounced in females than in males.

In adolescent boys the BMI continued to increase but a decrease in GMT points towards the limitation of BMI as an indicator of fatness, though when clubbed with skinfold thickness gives vivid picture. The simultaneous decrease in skinfold thickness but continuous increase in BMI could be because among the boys' magnitude of adolescent spurt is so high that the energy requirement is not met with daily intake, so the body calls upon the fat stores pointing towards an increase in muscle and skeletal mass at the cost of stored fat in the body. Parizkova[21] also observed lot of fluctuation for energy stores as fat is depleted in case of faster growth phase. An analysis of Tuzla boys ranging from 11–16 years shows that the mothers age affect the anthropometric properties of their sons and BMI indicates malnourishment[22].

The trunk/extremity ratio also establishes the fact that there is trend in favor of increase in trunk fat, more marked in boys than in girls as adolescent boys assume

TABLE 8
MOTHER-SON CORRELATIONS FOR VARIOUS ANTHROPOMETRIC VARIABLES IN DIFFERENT AGE GROUPS

Variable	Age (years)						
	11	12	13	14	15	16	17
Weight (kg)	0.295	0.252	0.049	0.152	0.028	0.012	0.148
Stature (cm)	0.133	0.174	0.135	0.024	0.080	0.167	0.090
Biceps SF (mm)	0.152	0.070	0.301	0.204**	0.326**	0.005	0.312*
Triceps SF (mm)	0.196*	0.159	0.061	0.062	0.099	0.040	0.272*
Subscapular SF (mm)	0.028	0.250*	0.025	0.056	0.043	0.293*	0.212*
Suprailiac SF (mm)	0.182	0.144	0.061	0.097	0.111	0.018	0.212*
Medial calf SF (mm)	0.223*	0.083	0.068	0.199*	0.042	0.040	0.115

*p< 0.05, **p< 0.05, SF – skinfold thickness

the pattern of adult males supplemented by the skinfold rankings[23]. This could make males more prone to cardiovascular and other diseases at an early age. Barli et al.[2] identified significant gender differences in anthropological measures in children of Turkey, an analysis agreeing with present study. Siddhu et al.[24] concluded prevalence of overweight and obesity among affluent children of Amritsar, India.

A study of a representative sample of the Canadian population[25] 7 to 69 years of age, reported significant 7-year stability of trunk-to-extremity skinfold ratio, adjusted for overall level of subcutaneous fat. Perusse et al.[26] found the amount and distribution of subcutaneous fat strongly aggregates in families' familial/genetic factors are more important in determining the amount and distribution of subcutaneous fat.

In the present data, which included adolescent children and their parents, it has been observed that there is a redistribution of fat away from extremity towards the trunk, a rapid occurring process in males than in females. The increases in BMI with age were more pronounced in females than in males, both at adolescence and adult stage. There was an increase in GMT in adolescent girls but not in boys. The trunk/extremity ratio in the above sample establishes the fact that the trend in favor of increase in trunkal fat is more marked in boys than in girls.

Fat distribution is genetic or not, can be judged by parent-offspring correlations. Kapoor et al.[27] studied parent-offspring correlations for body measurements and subcutaneous fat distribution in infants and adults; they observed that the pattern of fat distribution was under greater genetic influence than fatness level. According to Welon and Bielicki[7], there is an increase in parent-child correlations with age due to environmental effects. Katzmarzyk[28] in order to estimate degree of familial resemblance in anthropometric indicators of fatness and fat distribution studied 327 Caucasian populations from 102 nuclear families. The sibling and parent-offspring correlations were significant. There was no sex or generation difference in familial correlations. The pattern of correlations while generally includes no spousal resemblance but significant parent-offspring and sibling correlation suggests role of gene in explaining at least part of heritability.

Russel[11] reported correlation coefficients of parent-child and sibling-sibling for height and weight in a rural Guatemalan population of pre-school children showing higher correlation for siblings than for parent-child. Zverev and Chisi[29] found that 7,11,12 years girls were significantly taller than boys and at 15 years the trend is opposite, whereas in the present study boys maintain taller stature in all the age groups exception being 12 years, this could be attributed to the favorable gender bias of better nutrition for boys.

Hartz et al.[16] in heritability studies investigated the relative importance of heredity and environment on the expression of given trait. Bralic et al.[30] showed that parent and children overweight/obese had significant correlations and the correlations between fathers and children were stronger than between mothers and children. Commonly the results of heritability study are interpreted as the extent to which a given trait can be influenced by environment. For obesity, however, this interpretation is misleading because family environment, which consists of parental care and child rearing techniques, has an important bearing on childhood obesity.

Family variables appear to be the most important correlates of obesity. The risk of obesity increases in proportion to parental obesity. Although these data suggest a genetic basis, similarity of process of biologic parent-child progenies and those in adoptive combinations emphasize the importance of environment. The child's ability to cope with these factors will determine the differences in adult physique. The degree of resemblance varies with character, some showing more, some less[20].The variability of the morphometric traits in a population has an influence on the values of correlation between relatives. In the present study the relatively higher parent-child correlations for some of the skinfold thickness measurements in different age groups could be a pointer towards determinants of adult obesity.

Acknowledgements

Our sincere gratitude to Professor I. P. Singh for his invaluable guidance. The financial assistance offered by Indian Council of Medical Research is gratefully acknowledged. The authors are thankful to cooperation extended by the subjects during data collection.

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KORELACIJA RODITELJ-DIJETE ZA RAZLIČITE INDEKSE DEBLJINE U ENDOGAMNOJ INDIJSKOJ POPULACIJI

SAŽETAK

Istraživanje je provedeno na 1042 odrasle osobe i adolescenata oba spola (11–17 godina) iz obitelji srednje klase porijeklom iz područja Punjabi s prebivalištem u Delhiju, India. Za procjenu relativnog utjecaja genetičkih i okolišnih čimbenika na različite pokazatelje potkožnog masnog tkiva, uzeto je 7 tjelesnih mjera na svakom ispitaniku: težina, visina i debljine kožnih nabora na nadlaktici (nad bicepsom i tricepsom), na leđima (subskapularno), na trbuhu (suprailiačno) i na potkoljenici (sredina lista). Zabilježena je preraspodjela masnog tkiva od ekstremiteta prema trupu sa starenjem, koja je izraženija kod muškaraca nego kod žena. Povećanje indeksa tjelesne mase (BMI) sa starenjem bilo je izraženije u žena nego u muškaraca, i to i u adolescenciji i u odrasloj dobi. Srednja vrijednost debljine svih pet kožnih nabora (GMT – engl. »grand mean thickness«), povećavala se s dobi kod djevojaka dok je kod dječaka fluktuirala. Omjer količine potkožnog masnog tkiva na trupu i ekstremitetima povećavao se sa dobi kod oba spola ali je trend povećanja količine masnog tkiva na trupu bio izraženiji kod dječaka. Korelacije debljine kožnih nabora između roditelja i djeteta općenito su bile niske, a relativno visoke vrijednosti korelacija za pojedine kožne nabore upućuju na odrednice debljine u odrasloj dobi.