FAMILY STUDIES OF SOMATIC AND FUNCTIONAL CHARACTERISTICS IN THE POLISH RURAL POPULATION

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ABSTRACT: In the present investigation we were trying to determine the genetic and environmental conditioning of the chosen somatic and functional traits in Polish rural population during ontogenesis. In order to find out interactions between environmental and genetic conditions of the studied traits, classical methods of quantitative features were applied: correlation coefficients corrected by assortative mating in the chosen types of heritability were evaluated on their base, heritability coefficients of analyzed features were assessed. The biggest stability of the correlation coefficients was observed for the length-parameters. We did not noticed stronger genetic control of functional features in men. Mean-strong genetic control among analyzed traits was observed in: reaction time, space orientation and static strength expressed as relative and absolute strength.

KEY WORDS: C genetic determination, intra-familiar correlation coefficients, heritability coefficients

INTRODUCTION

The issue of mutual interactions of the genetic determinants and environmental somatic and functional parameters of man dates back to the last century. Understanding genotypic and environmental contributions to variation in somatic and functional characteristics is central to discussions in the sport sciences and human biology. Although progress in identifying candidate genes for somatic and functional characteristics is considerable [1,2,6,13,18], applications of this technology to studies of large samples are relatively limited. Initially, the possibilities of research proceedings were limited to a considerable degree due to the knowledge on molecular biology. However, with the progress in molecular research more and more papers on genetic markers in sport appeared. One of the first discovered genes was the ACE gene [6] which conditions achievements in endurance sports. At present, genetic markers responsible for build (GDF8, ADRB2, ADRB3, NPY, VDR, LPL, IGFI), dynamic phenotype (AGT, ADRB2, EDNI, ANG, TGFB1), muscle strength (GDF8, VDR, COL1A1), metabolism of glucose and insulin (ADRB3), as well as blood and fat economy (Apolipoprotein E) are described most thoroughly. Precise characteristic of individual genes was drawn up in the work by Cięszczyk [4].

To date, a good deal of information genetic contributions to functional characteristics is derived from studies of twins [17] (review over 600 publications) and families studies review [2, 11]. Considering these remarks we hope this investigation will contribute to better relationships between genetic and environmental conditioning of the chosen functional traits of man during ontogenesis.

MATERIALS AND METHODS

The aim of this study was to determine the strength of genetic control and environmental conditionings in Polish rural population. The material consisted of 245 nuclear families with 251 sons and 229 daughters aged 7-15 years of life, inhabitants of villages lying on rural area of Żywiec and Kielce province (South Poland). The numbers of pairs in particular type parents-child relations is 960 (Table 1). Investigations were conducted in the years 1996-2000, in the houses of investigated families (adults) and in school attended by children. Additionally, for the purpose of broadening of material, 1427 boys and 1448 girls, pupils of elementary schools from the same area were investigated. This procedure enabled Z-normalization and

TABLE I. THE NUMBERS OF PAIRS IN PARTICULAR TYPE OF RELATIONS

Relations	Numbers of pairs in two groups of children		Total***
	group I*	group II**	
father – son	133	118	251
father – daughter	107	122	229
mother – son	133	118	251
mother – daughter	107	122	229
father – child	240	240	480
mother – child	240	240	480
parents – son	266	236	502
parents – daughter	214	244	458
parents – child	480	480	960

Legend: * - 7-11 years boy and 7-10 years girls , ** - 12-15 years boys and 11-15 years girls, *** total 7-15 years

increasing number of siblings pairs. The investigation consisted of fundamental somatic and functional traits, possible to measure in home conditions.

Investigations carried out both somatic and fundamental functional traits (motor abilities). Morphological traits: body height (B-v) and weight, sitting height, upper extremities length (a-da), lower extremities length (B-sy), biacromial breadth (a-a), thight breadth (ic-ic), arm, stomach and subscapular skinfolds. Functional traits: static grip strength expressed as relative strength (F/kg mass), flexibility [5], reaction time, speed of movement (test "plate tapping" [5]), balance (test "falamingo balance" [5]), space orientation (cross - apparatus AKN 102) of Polish construction. Examined person had to press the buttons on the cross-lines pointed out by two lamps emitted lights stimuli from left and upper rows.

Fundamental statistical methods were applied:

1. Calculation of arithmetic means and SD values.
2. Fundamental methods of genetics of quantitative traits were applied to establish strength of theirs genetic control [2,13]:
   - Interfamilial correlation coefficients were calculated in all combinations of relationship using normalized, Z-values. This procedure enabled elimination of sex and age influences. Normalization was conducted in one-year groups in children and ten-years groups in parents,
   - Correlation coefficients were corrected according to assortative mating of an value

$$\frac{1+c}{\sqrt{2(2+c)}} - 0.5 ,$$

   where "c" is correlation between parents [2,13]. Definitely, c_{corr} values were used to the analysis of family resemblances. Because of small number of children in particular age and sex groups, calculations were made in two connected groups of children's age: 7-11 and 12-15 years. Significance of "r" values of intergroup differences of "r" were tested, too.
   - Heritability was determined by simplest method [2,13] $h^2 = 2\ c_{corr}$ (parent child correlation) they are approximate measure of heritability in a "narrow sense": Va/Vt. The regression of child on midparent is particularly useful because the heritability is estimated with least error and is not affected by assortative mating.

RESULTS

The subjects of our research were complete families that allowed for taking into consideration a correction following from assortative mating between parents and children at evaluating correlation coefficient in the given types of resemblance. In the case of presence of this type of mating – correlation coefficients are over higher, and as a consequence heritability coefficients are significantly higher. Measurement of assortative mating in our research was solely based on the indices achieved in the group of the youngest parents of studied children (till 35 years old). The drawback of many research is disregarding such kind of correction – that results in significant limitations in the comparisons inter-population indices of heritability, since their way of evaluation makes them much higher when positive assortative mating occurs. The magnitudes of correlation coefficients among parents achieved in our studies and corrections referring to the intra-familiar correlations were shown in Table 2 (n spouse pair = 76).

Generally, in the group of parents under 35 years old, selective mating appeared slightly – that is why the range of corrections referring to intra-familiar correlation coefficients will be undersized. Among the somatic traits the strongest assortative mating was revealed in biacromial and thigh breadth, in the group of strength parameters for strength expressed relatively [per kg of body mass].

TABLE 2. FATHER-MOTHER CORRELATIONS OF PARTICULAR TRAITS (ASSORTATIVE MATING IN GROUP <35 YEARS)

Trait	Age group	
	r_{pp}<35lat	correction
Body height	-0.08	0.03
Sitting height	0.05	-0.02
Lower extremities length	0.02	-0.01
Upper extremities length	0.15	-0.05
Thigh breadth	0.16	-0.06
Biacromial breadth	-0.20	0.08
Body mass	-0.03	0.01
Skin folds	0.05	-0.02
Flexibility	0.03	-0.01
Grip strength	-0.03	0.01
Relation strength/kg	0.16	-0.06
Reaction time	0.20	-0.08
Speed of movements	0.20	-0.08
Balance	-0.15	0.05
Space orientation	0.17	-0.06

Legend: r_{pp}- correlation father-mother

However referring to the coordination abilities – for the simple reaction time and movements frequency.

Adjusted for the impact of this mating correlation coefficients (C_{SK}) between parents and children in selected types of resembles are given in Table 3.

Their analysis concludes that in the population studied in selected types of resembles took considerable variation depending on the nature of the observed characteristics, sex of the parents and children and the age group of children. C_{SK} size are in the range of 0.01 (for balance in the father-son relationship in Group I) to 0.51 (for spatial orientation in the father-daughter relationship in Group I). For the sitting height there are observed larger values of correlation coefficients in the II age group in all types of resembles analyzed. Also for the other length parameters of the skeleton for the majority of cases, there is also somewhat higher values of correlation coefficients in the group II.

Also for hips width, in most cases, there is a greater volume of correlation coefficients in group II. The reverse relationship is noticed in the case shoulder width - for most types of resembles correlation coefficients higher values was observed in group I.

In own study slightly higher values of correlation coefficients were observed in Group II for: the skin folds, flexibility and the response time .

Other correlation coefficients for the rest of the tested traits do not show the general trends.

The size of the system by analyzing the correlation coefficients between mother - and a child and father - and a child say that, for most of the traits greater values of C_{SK} are found in II Group (especially in mother-child relationship). It is also interesting the size of correlation coefficients of parents and children with respect to gender.

For all the somatic and functional parameters in both age groups higher correlation coefficients are observed between parents and

TABLE 3. INTRA-FAMILIAR CORRELATION COEFFICIENTS IN TWO GROUPS OF CHILDREN AGE

Trait	Age group	Relation											
		f-s	f-d	f-ch	m-s	m-d	m-ch	p-s	p-d	p-ch	mp-s	mp-d	mp-ch
Body height	I	0.46	0.24	0.35	0.38	0.29	0.33	0.42	0.26	0.35	0.49	0.34	0.42
	II	0.36	0.26	0.31	0.41	0.39	0.40	0.39	0.32	0.35	0.40	0.36	0.38
Sitting height	I	0.36	0.17	0.26	0.38	0.26	0.32	0.37	0.22	0.29	0.44	0.32	0.38
	II	0.37	0.27	0.32	0.39	0.42	0.40	0.38	0.35	0.36	0.38	0.39	0.38
Lower Extremities length	I	0.19	0.24	0.21	0.48	0.44	0.46	0.32	0.34	0.33	0.43	0.42	0.42
	II	0.33	0.22	0.27	0.44	0.39	0.41	0.38	0.30	0.34	0.42	0.39	0.40
Upper Extremities length	I	0.21	0.08	0.15	0.12	0.11	0.11	0.17	0.10	0.13	0.20	0.19	0.19
	II	0.32	0.08	0.20	0.10	0.13	0.11	0.21	0.11	0.16	0.23	0.26	0.24
Thigh breadth	I	0.16	0.05	0.11	0.18	0.13	0.15	0.17	0.10	0.13	0.26	0.19	0.22
	II	0.12	0.25	0.18	0.19	0.32	0.25	0.16	0.28	0.22	0.20	0.33	0.27
Biacromial breadth	I	0.29	0.24	0.26	0.14	0.11	0.12	0.22	0.18	0.19	0.37	0.30	0.33
	II	0.13	0.12	0.12	0.19	0.13	0.16	0.16	0.12	0.14	0.39	0.18	0.28
Body mass	I	0.22	0.18	0.20	0.27	0.15	0.21	0.25	0.16	0.20	0.38	0.19	0.28
	II	0.13	0.21	0.17	0.16	0.26	0.21	0.15	0.24	0.19	0.26	0.29	0.27
Skin folds	I	0.13	0.25	0.19	0.16	0.22	0.19	0.15	0.24	0.19	0.24	0.35	0.29
	II	0,35	0.25	0.30	0.24	0.28	0.26	0.30	0.27	0.28	0.38	0.37	0,37
Flexibility	I	0.02	0.16	0.09	0.06	0.17	0.12	0.04	0.17	0.11	0.20	0.26	0.23
	II	0.13	0.24	0.18	0.34	0.17	0.26	0.24	0.21	0.22	0.37	0.23	0.30
Grip strength	I	0.23	0.31	0.27	0.22	0.16	0.19	0.23	0.22	0.23	0.37	0.41	0.39
	II	0.36	0.06	0.21	0.25	0.25	0.25	0.30	0.16	0.23	0.43	0.26	0.35
Relation strength/kg	I	0.17	0.16	0.17	0.12	0.08	0.10	0.15	0.12	0.13	0.27	0.40	0.33
	II	0.14	0.21	0.18	0.20	0.14	0.12	0.17	0.18	0.16	0.29	0.26	0.27
Reaction time	I	0.17	0.10	0.13	0.13	0.09	0.11	0.15	0.10	0.12	0.27	0.22	0.24
	II	0.28	0.11	0.20	0.26	0.12	0.19	0.27	0.12	0.19	0.44	0.13	0.28
Speed of movements	I	0.18	0.19	0.18	0.13	0.14	0.13	0.16	0.16	0.16	0.20	0.14	0.17
	II	0.16	0.12	0.14	0.34	0.36	0.35	0.25	0.24	0.25	0.32	0.30	0.31
Balance	I	0.07	0.18	0.12	0.28	0.30	0.29	0.18	0.24	0.21	0.30	0.04	0.17
	II	0.01	0.11	0.06	0.09	0.20	0.15	0.06	0.16	0.11	0.10	0.08	0.09
Space orientation	I	0.19	0.51	0.35	0.24	0.21	0.23	0.22	0.36	0.29	0.29	0.44	0.36
	II	0.25	0.22	0.23	0.32	0.17	0.25	0.28	0.20	0.24	0.44	0.32	0.38

Legend: f-father; s-son; d-daughter; ch- child; p- parents; mp-mid parents value

TABLE 4. HERITABILITY COEFFICIENTS OF PARTICULAR TRAITS IN RESEARCHED GROUPS

Trait	Age group	Boys	Girls	Total
Body height	I	0.84	0.52	0.70
	II	0.78	0.64	0.70
Sitting height	I	0.64	0.44	0.58
	II	0.76	0.70	0.72
Lower extremities length	I	0.64	0.68	0.66
	II	0.76	0.60	0.68
Upper extremities length	I	0.34	0.20	0.26
	II	0.42	0.22	0.32
Thigh breadth	I	0.34	0.20	0.26
	II	0.32	0.56	0.44
Biacromial breadth	I	0.44	0.36	0.38
	II	0.32	0.24	0.28
Body mass	I	0.50	0.32	0.40
	II	0.30	0.48	0.38
Skin folds	I	0.30	0.48	0.38
	II	0.60	0.54	0.56
Flexibility	I	0.08	0.34	0.22
	II	0.48	0.21	0.22
Grip strength	I	0.60	0.54	0.56
	II	0.46	0.44	0.46
Relation strength/kg	I	0.60	0.32	0.46
	II	0.30	0.24	0.26
Reaction time	I	0.30	0.20	0.24
	II	0.54	0.24	0.38
Speed of movements	I	0.32	0.32	0.32
	II	0.50	0.48	0.50
Balance	I	0.36	0.48	0.42
	II	0.12	0.32	0.22
Space orientation	I	0.44	0.72	0.58
	II	0.56	0.40	0.48

a son than in the relationship parents and a daughter. For most parameters higher C_{SK} were observed between the father - son relationship than the father - daughter. Visible discrepancy in C_{SK} size of functional parameters were noticed for the relationship mother and a son, daughter and mother. It is difficult to determine a clear trend here.

The subjects of the analysis were also values of corrected correlation coefficients of the children with the mid-parents' figures, which were presented in Table 3. It should be noted that the value received are consistent with theoretical model of quantitative polygenic inheritance. They do not exceed the theoretical values and are much higher than the relations analyzed separately with the parents.

For body height and the width of shoulder stronger associations were observed between the mid-parental amount and a group of boys than girls group. Also for the coordination abilities there are stronger relationships with mid-parental volumes in the case of sons than daughters. The parameters for the force, flexibility, body weight, there is no clear trend.

Correlation coefficients (C_{SK}) among parents and children that were corrected by assortative mating, were used to evaluate heritability coefficients. Their values are presented in Table 4. Generally in the given study, body height and sitting height had the strongest control. Heritability coefficients of these traits for boys were from 0.64 to 0.84, for girls - a little bit lower from 0.44 to 0.70. As a whole they were: 0.58-0.72. Lower heritability coefficients were achieved for the lower and upper extremities length (within 0.20-0.76).

The interesting issue is also the evaluation of the strength of genetic conditioning referring to the length - parameters considering gender aspect. The results of our study pointed out a little bit higher values of heritability coefficients in men of both age groups for all the traits. The analysis of the coefficients magnitudes all together (without sex dimorphism) results in their decreasing, whereas performing them as mean values leads to unclear differences among individuals of the results of both sexes. Mean – strong genetic control was performed in breadth- parameters of the skeleton – biacromial and thigh breadth.

Their heritability magnitudes were 0.20-0.56. Regarding also these group of somatic traits there were observed a little bit higher values of the heritability coefficients in men, which was a kind of surprise. Generally, in the whole material for almost all length and breadth parameters there was observed characteristic phenomenon of increment the strength of genetic conditioning with age.

The separate group of somatic parameters is body mass and skin folds. Both parameters had high heritability coefficients. Probably it was a result of ignoring correlation coefficients of environmental influence for both trials?

The subject of this analysis was also an assessment of genetic control regarding the strength-parameters. In our research we noticed, in the whole material, a little higher heritability coefficients of static strength than strength expressed as relative [per kg of body mass]. The heritability magnitude without gender aspect were within 0.26-0.56 and pointed out 'mean-strong' genetic control of these parameters. In majority of cases higher heritability coefficients were achieved in the group I of the studied children.

Within the analyzed coordination motor abilities 'mean-strong' genetic control characterizes space orientation (heritability coefficients 0.40-0.72) and speed of movement (0.32-0.50). Low level of heritability was noted for static balance (in the whole material, the coefficients were 0.12-0.48) and reaction time (0.20-0.54).

After the analysis of heritability coefficients of these traits regarding sex, we could conclude that consequently higher values of the coefficients appeared in boys than in girls in both age groups for: time reaction and speed of movements. In the rest of cases we did not observe a common tendency. Another interesting result referred to heritability coefficients affected by age and sex of the subjects. Hence: it was noticed with age an increase for time reaction and balance in both sexes. Generally, it was confirmed in our research the thesis of stronger control of functional traits in boys than in girls.

DISCUSSION

In this investigation there was taken out a trial of determining the mutual interactions between genetic and functional conditioning of the chosen somatic and functional parameters of man during the ontogenesis. Having as a material complete families, intra-family correlation coefficients were corrected by assortative mating. The study of this problem had a long tradition, as they have conducted since the beginning of XX century (review of 44 works [21], review over 600 works [17]). Extensive research embracing 3 generations in the Polish population was also carried out by Wolański and Pyżuk [28]. In their work there were included the values of correlation coefficients in the formation of parents and grandparents for 13 quantitative and 53 psychomotor traits together with the evaluation of their significance. Also in the work by Szopa et al. [24] considering a comparison of correlation coefficients referring to father – mother in 5 Polish family studies from 1981-1997.

The results of the study showed that for the analyzed traits: functional and somatic as well, assortative mating appeared in not significant extend. It was considerably lower than this observed in Polish rural populations from seventeen years in the last century [27,28]. It is worth to mention that in the research quoted above, correlation coefficients referring to the group of studied children's parents were evaluated only in the whole material, so they were incremented by so called "cohabitation effect" [2,13]. These regularities confirmed own research, where significantly higher magnitudes of the correlation among parents in the group of longer marriage stage were observed. However the results of our study are very close to the data of last new Polish and foreign investigations [2,16,24]. Thus relatively lower magnitudes of assortative mating of the analyzed traits that were noticed in this research, in the group of parents with short marriage stage allowed for summation that correlation coefficients presented are really a measure of selective mating among parents and that is why correction introduction to intra-families correlation coefficients was intentional.

As it was mentioned, as a measure of resemblance among parents and children we introduced corrected correlation coefficients in the given types of relativities. As a reference point for assuming the strength of genetic control of the functional traits there were used the data of fundamental somatic parameters that were known by strength of genetic control from lots of investigations [13,19]. Like in the majority of the publications quoted above – in our research the biggest stability and the values of heritability coefficients showed length-parameters of the skeleton. Mean-strong genetic control performed breadth-parameters of the skeleton. These groups of the traits served to interpret the heritability coefficients referring to analyzed functional traits.

The results of our research – similar to most comparable twins and families [2,17,24] mean-strong genetic control appeared in muscle strength. Slightly higher coefficients were achieved for strength expressed as absolute than relative strength.

The subject of the analysis was also a trial of evaluation the genetic control of coordination parameters. Within this group of coordination predispositions, the largest amount of research were recognized for genetic conditioning of simple time reaction determined on the base of twins study [9,10,15,17,20,22]. Whereas most research regarding heritability of simple time reaction based on family materials were carried out till this time in Poland [7,8,14,27,28]. From the previous investigations it was concluded that this trait was strongly determined genetically. However last studies (methodologically corrected) point out that this trait characterizes weaker genetic control. The results achieved in our study confirmed this thesis.

The other analysis referred to the movement frequency. Literature review on twins study [12,20] presented magnitudes of heritability coefficients within the values of 0.32 - 0.87. Such discrepancy is caused by significant differences in the number of twin couples and diverse methods of measurement. The same review showed that heritability values were higher in male twins than female. In family studies [3,7,8,28] also very high differences in heritability coefficients magnitude – from 0.01 to 0.72 were achieved. Our results demonstrated mean-strong genetic conditioning of this trait.

Relatively little amount of the study refers to space orientation. The studies of its strength of genetic control till this time were carried out only in Poland [7,8,14,20,23,27,28]. The outcomes of our own and comparable research illustrate its mean-strong genetic control.

Among the coordination predispositions, balance was another subject of the analysis. Assumed heritability coefficients from the studies of twins were within 0.12-0.78 [10,13,17,20,25,26] and were higher for static balance than dynamic one. Whereas in the previous family studies [28] there were achieved following magnitudes: $h^2 = 0.11$ for static balance and $h^2=0.37$ for pivot balance. However heritability coefficients of this trait in the last Polish family studies [7,8,24] were within 0.02-0.82. Also we gained in this research significantly variable heritability coefficients of balance from 0.12 to 0.48. For the summary we can pay attention to considerable differentiation of heritability coefficients depending on the way of measurement, population of the study and age group in which they were assessed. These discrepancies do not allow in the categorical way to determine the strength of genetic control of this trait and confirm necessary of further investigations.

CONCLUSIONS

1. Assortative mating among parents in our research appeared only in irrelevant extend. Hence the correction scale of correlation coefficients in analyzed types of resemblance parents-children was small.
2. The strongest genetic control within all analyzed somatic traits was revealed in length- parameters of the skeleton, then biacromial breadth and thigh breadth.
3. In the group of functional parameters 'mean-strong' genetic control was presented in: reaction time, space orientation and static strength expressed as absolute and relative strength. Significantly low heritability coefficients were observed for static balance.
4. The results of own investigation do not confirm the common statement about stronger genetic control of functional traits in male.

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