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Genes, constitution and culture versus fertility and survival in man

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RESUMO

Aspectos morfológicos, fisiológicos, psicomotores, nível de instrução do marido e mulher, rendimento familiar e condições de vida, número de gestações e de filhos sobreviventes em diferentes períodos de desenvolvimento, foram investigados em 250 famílias. A realização de análise factorial permitiu o estabelecimento de seis factores: F1 — educação, rendimento e índice de maturação feminina; F2 estrutura corporal da mulher e pressão sanguínea: F3 — estrutura corporal do marido; F4 — tamanho corporal das mulheres, capacidade toráxica e aptidão física; F5 — mortalidade e número de pessoas por quatro; F6 — idade ao casamento e diferença de idades entre os conjuges.

O ambiente familiar é o elemento mais influente na fertilidade; idade ao casamento e diferença de idade entre os pais são cruciais para a sobrevivência dos fetos; pais de fraca compleição física, boa saúde, educação e condições de vida são mais importantes na sobrevivência infantil; de um modo geral, boa aptidão física dos pais e estrutura elevada são factores decisivos para a sobrevivência da descendência.

Palavras-chave: Fertilidade; Cultura; Genes; Constituição física.

ABSTRACT

Morphological, physiological and psychomotor traits, education background of husband and wife, family income and living conditions, the number of pregnancies and survival of offspring in various developmental periods were investigated in 250 families. By factorial analysis six rotated latent factors were established: F1 = education, income and maturation rate of women, F2 = woman body build and blood pressure, F3 = husband body build, F4 = spouses body size, lung capacity and physical fitness, F5 = mortality and persons per room, F6 = marriage age and age difference between spouses. Family environmemt is the most important element for fertility; age at marriage and parents' age difference are crucial for fetus survival; weak-bodied parents, good health, education and living conditions are most important for infant survival; generaly — good physical fitness of the parents and tall stature are decisive for offspring survival.

Key-words: Fertility; Culture; Genes; Constitution.

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INTRODUCTION

Fertility and survival, the two indicators of how man adopts to his environment have been investigated extensively in our earlier studies along with studies on physiological adaptation by breathing and blood circulation.

Initially, we have examined 136 large-size families from the Kurpie and Suwaki regions in Northern Poland. We have found greater fertility in endogamic (born in the same place) families which were at the same time heterogeneous in Rh blood groups. Greater survival rate was observed in less fertile families (WOLAŃSKI, 1975, 1977). Next we have extended our research to 1,100 families living in the country, in industrialized and urban parts of poland. During that stage we have eliminated the education and income influences on the relationship between fertility and survival and biological traits of the mother. We have observed a connection between fertility and blood pressure and the relative chest circumference in women (the Marty index); we have also observed a selection aimed against the children of short mothers with medium and narrow face, low and high blood pressure, medium and high concentration of hemoglobin and hematocrit index, strong body and large fat tissue (WOLANSKI, 1982, 1984). This phenomenon was later on examined in greater detail with respect to net survival in the populations of Silesia (South-Western Poland) (WOLAŃSKI, 1983); the data were examined again with respect to survival in other stages of ontogenesis (SZEMIK, WOLAŃSKI, 1987). Also the regression of fertility and survival versus biological traits of the parents was calculated (SZEMIK, WOLAŃSKI, TATER, 1986). Other surveys covered the relationships in 273 families between ridge counts and pattern intensities of fingers, palms and soles and the number of pregnancies, number of surviving children, the mother's age at birth of the 1st child and miscarriages (LOESCH, WOLAŃSKI, 1985). The studies carried out so far prompted a synthesis of works dealing with the same subject (SZEMIK, 1987).

The present paper takes the problem further and analyses fertility and survival patterns in the light of a set of latent factors which include cultural and economic conditions of families and the biologiacal characteristic of parents. In our work we were guided by a conviction that explorations of the border area between biodemography (i.e., biolgical aspect of demographic processes) and the genetics of human populations constitute one of the two main territories of human ecology.

DATA AND METHOD

Of 1,100 families interviewed in six regions of Poland (Suwaki, Lublin, Bechatów, Zagebie, Dabrowskie, Lódź) only in 250 cases the data provided a complete set of information appropriate for the present study (one of the conditions has been at least one pregnancy). Next, we have used factor analysis

to examine the data on puberty, marriage, age difference between the spouses, education background, income and household conditions as well as the data on morphology, physiological and psychomotorcharacteristic of the spouses and their health. After the principal components had been defined for a clearer description of the latent factors we have aplied the Varimax rotation to obtain six rotated latent factors which then were used in the analysis of variance of fertility and survival of offspring in the families covered in the study.

Survival was assessed by for indexes four indexes where:

$$SI_0 = \frac{\text{number of pregnancies} = (\text{number of natural miscarriages} + \text{stillborn babies}}{\text{number of pregnancies}} \times 100$$

which describes survival during fetal period,

$$SI_1 = \frac{\text{no of pregnancies} - \text{deaths in the 1st mounth after birth}}{\text{number of pregnancies}} \times 100$$

which describes survival in early infancy i.e., when selection is strongly influenced by genetic reasons, congenital and genetic malfuntions,

$$SI_2 = \frac{\text{no of pregnancies} - \text{no of deaths between 2nd deaths between 2nd and 12 mounth}}{\text{number of pregnancies}} \times 100$$

which describes survival in later infancy when mortality is chiefly connected with enrironmental conditions (respiratory diseases, diseases of the alimentary canal, etc.),

$$SI_{total} = \frac{\text{no of pregnancies} - \text{no of total loses of fetuses and inf.}}{\text{number of pregnancies}} \times 100$$

The last index gives the sum total of the loses in one family i.e., survival in the reproduction period.

RESULTS

The first of the latent factors is most strongly correlated with hemoglobin concentration and spine elasticity of the men, spine elasticity of the woman, income per capita, education level of the men, breath rate at rest of the women and the age of the woman's puberty (Table 1). Considering the fact that education and income are related to somatic properties (WOLAŃSKI, 1987: the relation appears be indirect: early puberty, good physical development and good education are derivatives of the conditions of growth which in turn influence income) this factor could identify the intellectual level and family income. In this sense, a rise of F1 denotes a higher standard of general

TABLE 1: *Six rotated latent factors of properties of family and traits of wife and husband in Polish families (F1 — F2), their relation with each trait (factor loading) and common of each trait (h^2)*

TRAITS	F1	F2	F3	F4	F5	F6	h^2
Age at menarche	—0,41	0,03	—0,18	0,16	—0,11	—0,20	—0,39
Woman's age at marriage	—0,22	0,03	—0,10	0,02	0,14	0,62	0,47
Age difference of spouses	0,07	—0,10	0.02	0,06	—0,03	—0,66	0,45
Husband education	0,43	—0,02	0,16	—0,29	0.17	0,00	0,33
Working people per family members	0,05	—0,03	0,12	0,18	0,43	0,24	0,29
Persons per room	—0,25	003	0,18	—0,02	—0,40	0,25	0,32
Income per family member	0,49	0,04	—0,05	—0,05	0,35	0,18	0,41
Stature of wife	0,05	0,12	—0,04	—0,64	—0,02	—0,29	0,52
Stature of husband	0,13	—0,09	0,00	—0,56	0,11	0,19	0,39
Body weight of wife	0,08	0,84	—0,02	—0,19	—0,12	—0,10	0,78
Body weight of husband	0,05	—0,04	—0,84	—0,30	0,06	0,05	0,81
Chest shape of wife	0,12	0,52	0,07	0,18	0,19	0,23	0,41
Chest shape of husband	—0,02	0,000	—0,50	0,11	0,00	—0,01	0,27
Marty index of wife	0,07	0,78	—0,01	0,23	—0,08	0,11	0,68
Marty index of husband	—0,10	0,01	—0,86	0.08	0,01	—0,10	0,76
Adipose tissue of wife	0,25	0,77	0,03	0,04	—0,13	0,09	0,68
Adipose tissue of husband	0,13	0,01	—0,80	—0,04	—0,01	0,06	0,65
Hemoglobin concentration in wife	0,44	0,12	—0,07	0,10	—0,62	—0,06	0,62

TABLE 1: Cont.

TRAITS	F1	F2	F3	F4	F5	F6	h^2
Hemoglobin concentration in husband	0,56	0,11	—0,28	—0,17	—0,28	0,29	0,60
Hematocrit index in wife	0,03	0,07	—0,02	0.08	—0,70	—0,04	0,51
Hematocrit index in husband	0,21	0,02	—0,23	—0,24	—0,29	0,35	0,37
Systolic blod pressure in wife	—0,31	0,63	—0,04	0,19	0,07	—0,08	0,54
Diastolic blood pressure in wife	—0,29	0,56	—0,02	0,09	0,12	—0,17	0,45
Respiraton frequency in wife	0,43	0,00	—0,01	0,01	0,01	—0,01	0,19
Respiration frequency in husband	0,12	0,01	—0,04	0,19	0,16	0,01	0,08
Zimssen index in wife	0,00	—0,06	0,06	—0,61	—0,16	—0,08	0,42
Zimssen index in husband	0,04	—0,18	0,11	—0,58	0,06	0,08	0,40
Spine flexibility in wife	0,48	0,06	0,12	0.06	—0,08	—0,06	0,26
Spine flexibility in husband	0,50	—0,09	—0,13	—0,06	0,06	—0,13	0,30
Grip strength in wife	—0,22	0,05	—0,06	—0,55	—0,26	—0,09	0,43
Grip strength in husband	0,09	—0,06	—0,22	—0,55	0,17	0,04	0,39
Reaction time in wife	—0,03	0,15	0,02	0,29	0,04	—0,08	0,12
Reaction time in husband	—0,12	—0,01	—0,04	0,36	—0,07	—0,28	0,23
Cephalic index in wife	0,37	—0,06	0,07	0,11	—0,09	—0,11	0,18
Cephalic index in husband	0,28	0,14	—0,03	—0,08	—0,10	0,13	0,13
Number of diseases in wife	0,02	0,13	—0,13	0,01	0,11	—0,28	0,12
Number of diseases in husband	—0,08	0,19	—0,15	0,00	0,41	—0,18	0,27
Identification of latent factor	**culture (conscious. ness and income) of family**	**body build and blood pressure of wife**	**body build of husband**	**size and physical fitness of spouses**	**health and living conditions**	**marriage age and age difference of spouses**	

culture in the family. Factor F1 accounts for 9.81% of the common variance of variables.

The second factor (F2) is most strongly correlated with body weight, fat tissue, blood pressure and flatness of the chest in the women. A rise of F2 (Table 1) means tall stature, fatness, high blood pressure and a rounded chest in the women. F2 explains 8.7% of the common variance of the variables.

The next factor (F3) is correlated with the Marty index (Circumference of the chest as percentage of stature), body weight, fat tissue and flatness of the chest of the man. Higher values of F3 mean a weaker frame of the man's body. It explains 8.7% of the common variance of the variables.

Factor 4 is correlated with stature, the Zimssen index and muscle strenght of the spouses. Its rise means smaller stature, worse lung development (the Zimssen index is the ration of lung capacity to stature), and litle muscle strength of the husband and wife. F4 explains 5.63% of the common variance.

F5 is most strongly correlated with blood porperties of the woman, the number of bread-earners per one member of the family, persons per one room and, to a lesser extent, with family income. A rise of F5 should be tied to bad health (sick husband and bad blood indicators of the wife) but at the same time to professional mobility and good living standard. F5 explains 5.32% of the common variance of the variables.

F6 is most strongly correlated with age difference between the spouses and the age of marriage for the woman. Its rise corresponds to a marriage of an older woman and a small age gap between the spouses. F6 explains 4.65% of the common variance.

Between them the six factors explain nearly 41% of the common variance of the variables. The method says that the first factor is stronger and more general than the second, the second is stronger than the third and so on, but the factors themselves are not correlated to one another so each and every factor alone covers independently some area of information about the variables under investigation.

Fertility (measured by the number of pregnacies) is significantly determined by F1, F3 and F5. Numerous pregnacies occur in families where the general standard of culture is low and so is income, the wife reached puberty at a later period what might suggest substandard living conditions but also simply a slow pace of biological development. Such women breath slowly and their spinal culumn is less flexible, while their husbands have a similarly litle flexible backbone and low concentration of hemoglobin in blood. These features could suggest some particular kind of profession of job as well as a specific pattern of life. F1 explains 8.44% of the variance of pregnancies. Also numerous pregnancies are characteristic for families where the man is well--built (large relative chest circumference, big weight and thick fat tissue and a rounded chest). F3 explains 3.43% of the variance of pregnancies.

Numerous pregnancies are also characteristic for the families where (F5) the woman has good blood indicators, the man is healthy, while they they share an overcrowded apartment and have only small income. This could be

interpreted as good health but poor living conditions. F5 explains 3.46% of fertility.

The above factors (F1 + F3 + F5) explain 14.3% the fertility of women under investigation.

Survival of fetuses is clearly related (from the factor under investigation) to F6. Its survival is conditioned by such things as ealry marriage and big age difference between spouses. F6 explains 2.44 fetus survival.

During the first month after birth i.e., during the period of greatest death rate caused by disorderly constitution or malfunctions either of genetic nature or developed during fetal period, the survival of the infant is related to factors F3, F2, F5. Factor F3 indicates that survival increases with weak constitution of the father i.e., small and flat chest, small body weight and thin fat tissue. F3 explains 2.14 of survival at that age. Survival at the first month after birth is also favoured by weak frame of the mother, i.e., small weight, small and flat chest, litle fat and low blood. This factor explains for 2.09% of survival. Survival improves with good health of the parents indicated by few reported ilnesses (especially of the father), good blood picture of the mother and also when the mother is not a bread-winner but stays at home (indirectly suggested by a low index of professionally active members of the family per capita), survival at early infancy is not effected by low income and is helped by over-population in apartments. The last factor seems litle surprising but, as suggested elsewhere, it usually concerns flats in new buildings where the standard is high and better sanitary conditions (WOLAŃSKI, CHRZASTEK-SPRUCH, TETER, 1987). This factor explains 1.44% of early-infancy survival. Altogether the above factors explain 5.67% of survival in «endogenous infant selection».

Two-to-twelve month old infants survive more frequently in families characterized by a generaly high cultural standard and high income. This concerns children born to mothers who reached early puberty (clearly girls either from well-off families or quickly maturing), both parents have flexible spines (maybe both parents had a lot of physical exercice), the father shows a high concentration of hemoglobin and a fast breathing mother. These characteristics of F1 factor explain 2.38% of infant survival. The other factors are negligibly related to survival of infants.

We have also examined the conditions of survival of children up to puberty i.e., the ones responsible for low reproduction loses and increasing chances for future reproduction of the family. Generally survival is increased by factors F4 and F2. Another words the overriding thing is large body size of parents, good breathing (the Zimssen index) and strength. This factor explains 4.16% of child survival. Factor F2 explains 2.93% of child survival. Chances of survival are increased by weak physical condictions of the mother i.e., low body weight, small and flat chest, little fat and low blood pressure. These features are somewhat surprinsing, but it could be that such mothers are more caring for their children or maybe it is related to the kind of job they are doing or their professional activity (non-professionally mobile women are more often found among that group i.e., mothers taking care their children are staying at home).

TABLE 2: *Contribution of six rotated latent factors to multiple regressions of fertility and survival index in fetus (SI_0), in early infancy (SI_1), in 2-12 month old infants (SI_2) and total survival of offspring in families under study (SI_{total})*

Regression and variance	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Identification of factor	culture and income of family	body build and blood pressure of wife	body build of husband	size and physical fitness of spouses	health and living conditions	marriage and and age difference of spouses
Number of pregnancies, N= 250						
Regression coefficient, b	—0.4366	0.0933	—0.2643	0.0200	—0.2297	0.1437
Standard error (b)	1.345	1.403	1.381	1.406	1.388	1.399
Significance, P	0.001	0.3	0.01	—	0.01	0.1
% of pregnancies explained	8.44%***	0.40%	3.43%**	0.02%	2.46%**	0.98%
Survival index in fetus, N= 250						
Regression coefficient, b	0.2435	—0.6264	0.7836	—0.8391	—0.0185	—2.1487
Standard error (b)	13.33	13.32	13.31	13.21	13.34	13.17
Significance, P	0.5	0.5	0.4	0.4		0.01
% of fetus survival explained	0.03%	0.20%	0.34%		0.00%	2.44%**

TABLE 2: Cont.

Survival index in early infancy, N= 250						
Regression coefficient, b	0.1253	—0.9342	0.9190	—0.4099	—0.7735	—0.6309
Standard error. (b)	6.180	6.116	6.115	6.170	6.137	6.151
Significance, P	0.5	0.02	0.02	0.4	0.05	0.1
% of 1 month infants survival explained	0.04%	2.09%*	2.14%	0.38%	1.44*	0.98%
Survival index in 2-12 month infant, N= 250						
Regression coefficient, b	1.0031	0.3077	0.3005	—0.2061	—0.5073	0.4052
Standar error (b)	6.014	6.079	6.079	6.083	6.067	6.074
Significance, P	0.01	0.45	0.4	0.6	0.2	0.2
% of 2-12 month old infants survival explained	2.38%**	0.23%	0.24%	0.10%	0.64%	0.42%
Total survival index of children, N= 250						
Regression coefficient, b	1.3240	—3.5482	1.1119	—4.3249	—0.7253	—2.3149
Standar error (b)	19.78	1953	19.79	19.40	19.81	19.69
Significance, P	0.4	0.01	0.4	0.001	0.6	0.08
% of children survival explained	0.39%	2.93%**	0.31%	4.16%***	0.12%	1.28%

DISCUSSION

The picture emerging from the above analysis is to say the least somewhat peculiar. The greatest fertility is found among low culture-and-income families and, judging by the fact that women in those families reached puberty relatively late, they must have grown up in poor living conditions. This regularity is quite well described in literature discussing whole populations — reproduction is higher among people from groups and social strata characterized by frequent sexual contacts and low use of contraceptives. Another characteristic feature is small elasticity of the backbone which could indirectly suggest strong body build and seems to be supported by factor F5; this, in turn, might point to the working class and farmers (at least in second generation) as indirectly suggested by late puberty among women. The picture is complete when we add overpopulation is apartments.

Let us recall our earlier studies revelealed a relation between fertility and several traits in the mother. In small towns of Zagabie Dabrowskie, higher fertility rate was observed in women who wre short, dolihocephalic, narrrow faced, strong bodied, with medium fat tissue, a large and rounded chest and high blood pressure, (WOLAŃSKI, 1982, 1984, 1985), however, it is only for blood pressure and relative size of the chest that fertility was not as the same time significantly correlated with education level of the parents and family income (WOLAŃSKI, 1984). In rural areas, a significant relation was discovered between low blood pressure of the mother, small relative lung capacity and low pulse pressure and high fertility rate (SZEMIK, WOLAŃSKI, 1987). It was also established in that survey that a high fertility rate in rural families was also observed for short, fat, medium weight mesocephalic fathers with medium-chest. A subsequent study based on multiple regression method the Zimssem and Marty indices for the mother played an important role, while regression equations calculated on those indices explained 13% of fertility (SZEMIK, WOLAŃSKI, TETER, 1986). However, there still persist some doubts whether the somatic traits of the mother were not also a reflection of the socio-economic status of the family.

The present analysis brings important corrections thanks to the use of uncorrelated factors. Fertility seems to depend decisively on the cultural and economic background of the families which were considered in over 8% in the analysed intra-familial factors. However, it also follows from the analysis done indenpendently of the economic and cultural factors that fertility depends in 3.4% on somatic traits of the father in 2.5% of the mother. This enequality seems to suggest that in addition to the biological understanding of fertility, the father's job could be meaninful here as could also be such things as degree of family care considered in factor F1.

According to our earlier studies more fetuses survived in Zagebie region when pregnant women were tall, short-headed (brachycephalic), broad-faced, with medium blood pressure, a high concentration of hemoglobin and high hematocrytic index, weak muscles and low endurance (persisitence fitness; from among the above the shape of the face, muscle strength and endurance

were not connected with cultural and economic background (WOLAŃSKI, 1984). In the rural environment the following traits of both parents proved important: stature, medium chest and head (mesocephalic); as concerns the mother also small weight, medium fat tissue, small relative lung capacity and high pulse pressure, while for the fathers: big weight, small fat tissue, large relative lung capacity and high blood pressure SEMIK, WOLAŃSKI, 1987). In multiple regression, a significant element was body stature and diastolic blood pressure (SZREMIK, WOLANSKI, TETER, 1986). The present study introduces some corrections to our previous results and indicates the importance of the age of marriage and the age gap between the spouses. The other factors turned out to be irrevelant; factor F6 explained only 2.4% of survival.

While searching for the conditions of survival we have introduced in previous studies various age divisions for the first months and years after birth. The surveys in the small towns of Zagebie showed that a higher mortality rate around borth time and during the first year was similarly conditioned i.e.: it was higher among tall, brachyecphalic woman with broad faces, medium blood pressure, low hemoglobin cocentration and low hematocrit index, little muscular strength and medium persistence fitness/endurace. Of these statistical significance of the findings was determined only with the relation to the shape of the face, hemoglobin concentration, hematocrit index and muscular strength which at the same time proved unrelated to education level and family income (WOLAŃSKI, 1982, 1984). Survival since birth up to the first year was connected in rural populations with tall stature, big weight, litle fat, medium chest, short head, high blood and pulse pressure in the mothers and, short stature, small weight, little fat, flat and small chest, dolichocephaly and low pulse pressure in the fathers (SZEMIK, WOLAŃSKI, 1987).

Multiple regression pointed to a relation between survival and relative body weight and chest circumference, and the equation also included the number of pregnancies; it esplained as much as 50% of infant survival (SZEMIK, WOLAŃSKI, TETER, 1986). In the present survey we have divided infancy into early infancy (endogenous mortality) and late infancy (exogenous mortality) and we have demonstrated that survival is most strongly conditined by the fetuses under investigation. Next, the present analysis clearly draws a line between conditions during 2nd-12th months when survival depends nearly exclusively on the cultural level and income in the family and conditions for the 1st month after birth when survival is connected with weak body frame of both parents, their good health and an overpopulated apartement, the later probably connected with new housing conditions in urban areas.

Different divisions were applied earlier also to the period of chilhood in our analyses of survival.The results obtained for children from 1 year to puberty were similar to the present findings for the townlets of Zagebie, and pointed to greater survival rate of the offspring of tall, brachycephalic women with broad faces, medium blood pressure, low hemoglobin concentration and low hemotocrytic index, weak muscles and large endurance (persistence fitness, but significant relations were found independently of education and

income) for the shape of the face and blood characteristic (Hb and Hct) (WOLAŃSKI, 1982, 1984). In rural populations higher survival role for the analogous time span was observed among the offspring of tall mothers with small body weight, small fat tissue, flat medium circumference of the chest, high blood and pulse pressure, and for the average stature and weight fathers with small fat tissue, rounded as chest, dolichocephalic and with low pulse pressure (SZREMIK, WOLAŃSKI, 1987). Multiple regression indicated the revelance of systolic and diastolic blood pressure which explained as much as 23% of child survival (SZREMIK, WOLAŃSKI, TETER, 1986). Present surveys also stress the role of specific characteristic of the parents: childhood survival is connected with weak body build of the woman but also with the stature and physical fitness of both parents.

Further surveys should focus on the interation of the genetic factor with the constitutional and environmental factors in the determination of fertility and survival. It appears too, that the biological determinants of fertility which relate to the species are relatively little significant for fertility and survival in general, instead there exist determinants specific for different populations.

Some of our results are not yet fully explained. The positive influence of small-sized apartments was interpreted in the following way: we assumed that overcrowded apartements (as compared to a national sample) were characteristic for new housing estates. The same problem emerged earlier when we were surveying populations in Lublin (WOLAŃSKI, CHRZASTEK-SRUCH, TETER, 1988. The positive effect was probably due to the sanitary standard and the kind of social strata coming to live in those new housing estates. These are quite frequently immigratory people more ecosensitive while their offspring may in quite a few cases heterogenous.

Another mystery is the positive impact of the the young mother. Our previous surveys indicated that it was best for the baby to have a 25-32 year old mother. This is a complex problem. A mother giving birth to a child at a young age probably got married earlier because she had reached puberty at a younger age. This in turn could suggest that she came from a better-off and better educated family. This factor might positively bear on the survival of the fetus. Another favourable factor would be the greater age fifference between the parents which confirms our earlier findings. It appears that the young age of the mother should be related to her cultural background and accompanying material standard, the level of hygene etc., while an older father probably guarantees proper responsability and readiness for his role.

Finally, the small body build of the mother or even both parents could be related e.g., to the fact that such people are more sensitive to their own health problems; they are less dynamic outside the family and more active within it — this might give them more experience for a more caring attitude toward their offspring. The analysis suggests that such parents are physically fit. These questions require further study.

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