Parent-Offspring Correlations of Sexually Matured Time, Body Height and Weight in an Albanian Human Population

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Abstract *Few studies have evaluated the heritability on sexually matured time (SMT) in comparison with that on height and weight. Body height and weight measurements and self-reported data of STM were obtained from Shkodra University students and their parents. The age at first menstrual period or menarche (AM) and at the first ejaculation or andrarche (AA) were used as indexes of SMT. Female students and theirs mothers AM resulted 13.44 and 14.12 years old, respectively. The difference was statistically highly significant, demostrating a decrease trend of SMT. Male students and their fathers AA were 14.14 and 15.63 years old, respectively. This difference also resulted highly significant. These findings showed that the acceleration of SMT is present in Albania for both sexes. Parent-daughter correlation coefficient for SMT was 0.4, parent-son correlation one was 0.41, while the SMT estimated heritability was 0.48, indicating that SMT is highly heritable trait in both sexes. It was notable that mother-daughter correlation (0.54) was much higher than father-daughter one (0.12). The body height of male students and their fathers was 172.8 cm and 171.5 cm, respectively, showing no significant difference. The body height of female students and their mothers were 164 cm and 162.2 cm, respectively. This difference resulted significant, indicating an increase trend of body height in females. The estimated heritability of body height resulted 0.76. Meanwhile the body weight one resulted 0.38, considerably lower than that of height. These preliminary heritability values, estimated for the first time in Albanian population, resulted compatible with other reports.*

Key words: *sexually matured time, body height, body weight, heritability, Albanian population*

1. Introduction

The widespread use of anthropometry remains significant in the field of medicine and biosocial sciences about describing and understanding the variation of growth, health pattern, nutritional status and well-being for entire population.

Human growth assessment is an essential part of auxology and in general it has been characterized by continuous outcomes like traditional measures of height and weight and discrete outcomes like Tanner stages of pubertal development, age at menarche (time of first menstrual period) and age at andrarche (time of first ejaculation), markers of infant development, visual acuity, etc., using them as anthropometric parameters. These outcomes are influenced by the interaction of many factors including hereditary factors, internal secretion of hormones, nutrition and psychological environment (Ramirez et al., 1991; Grilo & Pogue-Geile, 1991; Allison et al., 1996; Fabsitz et al., 1994; Biro et al. 1995; Reed & Price, 1998; Pietilainen et al., 1999; Luke et al., 2001). That is the reason why growth curves from investigations of height and weight distribution have a complex pattern and several models have been proposed to describe it. Several family studies, especially among twins, have revealed greater genetic control for height but greater environmental conditions for weight. Some studies have found evidence for maternal inheritance of female height (Boldsen & Taylor, 1990).

Age at menarche (AM) and age at andrarche (AA) are important developmental milestones in females and males, respectively. These human discrete outcomes for most of the authors have been considered a secure evidence of the sexual maturity achievement. As a part of the growth, development and maturity processes, the occurrence of menarche and andrarche has resulted to be under the combined influence of the genetic and environmental factors (Tanner, 1962; Kurdzielewicz, 2001; Anderson et al., 2007; Semiz et al., 2009). Because these two biological traits have important cultural, social, and epidemiological implications, increasing attention has been recently payed by scientists to understand the causes of age variations in the timing of AM and AA. Although results are not always consistent, several factors have been shown to significantly influence age at menarche, such as: genetic parameters (Danker-Hopfe & Delibalta, 1990; Kaprio et al. 1995), socio-economic conditions (Belmaker, 1982; Padez, 2003), general health and life-style (Brown et al., 1996), nutritional status (Tanner, 1962; Osteria, 1983; Riley 1994; Simondon et al., 1997), seasonality (Boldsen, 1992; Gueresi, 1997; Kopliku & Bajrami, 2005), physical activity (Malina, 1983; Malina & Bouchard, 1991; Baker, 1985), and

altitude level (Beall, 1983; Kapoor and Kapoor, 1986; Gonzales and Villena, 1996).

Positive secular trends in height and weight increase and sexually matured time decrease have been documented among many of world's populations. In many countries the trends are associated with: continuing economic development, social and health improvement, increase of food quality and security, declining prices for energy dense foods, progressive mechanization of the majority of labour-intensive jobs, sedentization of work replacing labour-intensive production jobs, mechanization of transport, sedentization of leisure time, increase of immunization status, mostly in childhood, psychological stress increase, etc., (Tanner, 1962; Ramirez et al., 1991; Grilo & Pogue-Geile, 1991; Rotimi & Cooper, 1995; Herskind et al., 1996; Kim & Smith, 1998; Popkin, 1999; Bagga & Kulkarm; 2000; Cole, 2000; Ellis et al., 2000; Hulanicka et al., 2001; Freedman, 2002; Padez, 2003; Kobzova et. al., 2004; Anderson & Must, 2005). Most of these factors are conditioned historically, culturally and politically by poverty and socio-economic status of different countries.

Heritability is an important statistical concept in quantitative geneticsand it is determined by estimating the relative contributions of genetic and environmental factors to the observed phenotypic variation of traits in a population. The percentage heritability, which is the proportion of phenotypic expression, due to genetic factors, varies for different traits and in different species even for the same trait.

There are few data available concerning the evaluation of heritability on height and weight in comparison with that on sexually matured time (Kaprio et al., 1995). The present investigation was performed to identify for the first time the secular trend and to estimate the heritability on height and weight in comparison with that on sexually matured time by studying parent-offspring differences of these anthropometric parameters in a sample of the Albanian population.

2. Material and methods

In a cross-sectional and retrospective study, possible secular trend and the heritability of body height and weight and sexually matured time as AM in females and AA in males were evaluated on data collected by measurements and questionnaire, involving 250 students (females 155 and males 95, born from 1986 to 1989) of Shkodra University (Albania) and their parents (mothers and fathers born from 1960 to 1970 and from 1953 to 1964, respectively). All students came from 12 districts of North Albania (Fig. 1), 134 of them living in rural area and 116 in urban centers.

The students and parents age was calculated from the date when questionnaire was done and respective birth dates. The age at menarche (AM) in females and the age at andrarche (AA) in males were used as indicators of sexually matured time of subject. The students and parentsAM and AA were calculated by differences between the occurrence of first menstrual cycle in female and ejaculation in male and respective birth dates. The differences were expressed in decimal system (1 month=0.083 years). Concerning body height and weight measurements of parents, the data were based on the past information (when they were the offspring age).

Fig. 1 Map of 12 Albanian districts involved in the questionnaire (red points)

Body height, weight, AM and AA mean values of offspring and the parents were calculated and compared in father-son and daughter, mother-son and daughter and mid-parent-son and daughter relations, using statistical Student's *t* test and 0.01 as level of significance. Mean values of mid-parents were calculated as average of parents mean values for each anthropometric parameter. The comparison of mean values was used to identify the trend of body height, weight, AM and AA between parents and their offspring.

The analyses of body height, weight, AM and AA parameters in father-son and daughter, mother-son and daughter and mid-parent-son and daughter correlations were done using linear regression method.

Heritability (h^2) was estimated by comparing parent and offspring traits based in analyzed correlations. The coefficient of regression line (r) approximates the heritability of the traits taken in account when female or male offspring values are regressed against the average values in the parents (mid-parent values):

$$h^2=r$$

If only one parent's value or both female and male offspring values are used, then heritability is twice the coefficient of regression:

$$h^2=2r$$

3. Results and discussion

3.1 Trend identification

Body height and weight, AM and AA data were collected from measurements and questionnaires. The proportion of censoring was 15.9%.

3.1.1 Body height

The results taken from analyzing data of body height measurement of the sample are shown in table 1.

Tab. 1 Overview of body height statistical data

Sample	N	Body height (in cm)	
		X ± SD	Range
Female students	155	164 ± 5.1	152-175
Mothers	154	162.2 ± 4.7	151-173
Fathers	155	175.4 ± 5.1	168-188
Male students	95	172.8 ± 6	162-185
Mothers	95	163.8 ± 3.4	153-168
Fathers	95	171.5 ± 4.1	160-180

The average body heights of female students and their mothers were 164 and 162.2 cm, respectively. The difference 1.8 cm resulted significant in females (t_s = 5.81 and α = 0.01). Meanwhile the average body heights of male students and their fathers were 172.8 and 171.5 cm respectively, showing no significant diffrence in males (1.3 cm, t_s = 1.73 and α = 0.01). The results identified a positive trend of body height increase in females born between 1960-1970 and 1986-1989, but not in males, maybe because of smaller size of male subject. However, the values range in both sexes has shown compatibility whith the above mentioned trend of body height (Tab 1).

3.1.2 Body weight

The results taken from analyzing data of body height measurement of the sample are shown in table 2.

Tab. 2 Overview of body weight statistical data

Sample	N	Body weight (in kg)	
		X ± SD	Range
Female students	155	57.7 ± 5.7	47-78
Mothers	154	59.3 ± 6.6	45-75

Fathers	155	73.9 ± 8	65-94
Male students	95	172.8 ± 6	55-83
Mothers	95	163.8 ± 3.4	46-70
Fathers	95	171.5 ± 4.1	57-85

The average body weights of female students and their mothers were 57.7 and 59.3 kg, respectively. The difference 1.6 kg resulted not significant in females (t_s = 2.3 and α = 0.01). Meanwhile the average body weights of male students and their fathers were 83 and 85 kg, respectively, showing non significant diffrence in males (2 kg, t_s = 2.66 and α = 0.01). The results did not identify a positive trend of body weight increase between both females and males offspring and parents.

3.1.3 Sexually matured time

The results obtained from analyzing data of body height measurement of the sample are shown in table 3.

Tab. 3 Overview of statistical data in sexually matured time

Sample	N	Sexually matured time (years)	
		X ± SD	Range
Female students	155	13.44 ± 1.05	10.08-15.75
Mothers	154	14.12 ± 1.12	12.58-17.5
Fathers	155	15.22 ± 1.01	13.17-17.75
Male students	95	14.14 ± 0.92	12.91-16.08
Mothers	95	14.31 ± 0.97	13-17.67
Fathers	95	15.63 ± 1.03	13.33-17.9

The average AM of female students and their mothers were 13.44 (13 years and 5 months) and 14.12 years old (14 years and 1 month), respectively. The difference 0.68 years (8 months) resulted highly significant (t_s = 5.44 and α = 0.01). Meanwhile the average AA of male students and their fathers was14.14 (14 years and 2 months) and 15.63 years old (15 years and 8 months), respectively, showing highly significant diffrence in males (1.49 or 1 year and 6 months, t_s = 9.3 and α = 0.01). The results identified a strong positive trend of sexually matured time decrease between both females and males offspring and parents, notably in males. The values range of SMT was consistent whith the above mentioned trend (Tab 3).

3.2 Heritability estimation

The analysis of body height and weight, AM and AA values of father-son and daughter, mother-son and daughter and mid-parent-son and daughter correlations were done by using linear regression method ($p<0.01$). An overview of regression coefficient in analysed correlations was shown in table 4. The results for body weight indicated highest positive correlation in mother-daughter (r=0.48), mid-parent-daughter (r=0.354) and father-son (r=0.32). Meanwhile, body height analysis showed highest coefficient of regression in father-son (r=0.62), mid-parent-son (r=0.518), mother-daughter (r=0.4), mid-parent-daughter (r=0.388) and mid-parent-offspring (r=0.38) correlations. It is to be noted that father-son correlation was much higher than mother-son one. Concerning sexually matured time, highest correlation were observed in mother-daughter (r=0.537), mid-parent-daughter (r=0.45) and mid-parent-son (r=0.41). Mother-daughter correlation was also much higher than father-daughter one (r=0.12). In general, mother-son and father-daughter correlations have the lowest regression coefficientsfor all parameters.

The comparison of all analysed correlations has indicated that body height was the strongest parent-offspring correlated parameter.

Heritability was estimated by comparing parent and offspring traits based in regression coefficient of analyzed correlations (Tab. 4 and $h^2=2r$). The heritability value of investigated traits resulted: 0.34 for body weight, 0.76 for body height and 0.48 for sexually matured time, being compatible with other reports (Kaur & Singh, 1981; Allison et al., 1996; Fabsitz et al., 1994; Doughty & Rodgers, 2000; Rowe, 2000; Luke et al., 2001; Morris et al., 2011). Based on daughter-parent and son-parent correlations ($h^2=r$), the respective heritability values of body height were 0.388 and 0.518, respectively, while for sexually matured time 0.45 and 0.41, and for body weight 0.357 and 0.237, respectively. The

lowest heritability values of body weight indicated that the observed variation of this parameter was the more influenced by environmental factors than the ones of body height and sexually matured time.

Tab. 4 Overview of regression coefficient in analysed correlations

Sample	Coefficient of regression r		
	Body weight	Body height	Sexually matured time
daughter-mother	0.480	0.400	0.537
daughter-father	0.031	0.210	0.120
daughter-mid-parent	0.354	0.388	0.450
son-mother	- 0.175	0.200	0.190
son-father	0.320	0.620	0.328
son-mid-parent	- 0.237	0.518	0.410
offspring-midparent	0.170	0.380	0.240

In the present study it was investigated and determined for the first time the age at andrarche in males and the heritability of body height, weight, and sexually matured time in a sample of the Albanian population, while there are few studies which have evaluated the age at menarche in females and its correlation with body height and weight of subject (Kopliku and Bajrami, 2004; 2005; 2009). Mean ages at menarche and at andrarche vary substantially between females and males across different countries and across different ethnic groups (Belitz, 1977; Hunt & Newcomer, 1984; Danker-Hopfe, 1986; Ulijaszek et al., 1991; Morabia & Costanza, 1998; Thomas et al., 2001; Freedman, 2002; Padez, 2003). Reasons behind this international variability remain poorly understood, mainly because few comparative analyses have been conducted on such a large scale (Morabia & Costanza, 1998). Most investigations of the relationships between ages at menarche and andrarche and their causes have been studied on a small scale by social scientists, anthropologists, or public health epidemiologists. However, the variables affecting the timing of these events within populations do not necessarily explain differences between populations.

Concerning body height and weight, there are some specific details of international differences that are important. It does seem that nowadays the average body height of American whites has stopped increasing. Meanwhile Northern Europeans keep getting taller (there are some discussions whether high levels of milk consumption are responsible for Dutch body height). (Steckel, 1994; Cole, 2000; Fredrics, 2000). Environmental input may have reached the time of diminishing returns on height in the developed world (Luke et al. 2001). The reason that the heritability of body height is lower in poorer nations or developing countries than in wealthy nations is that in the former there are still environmental factors which cause some variance in height. In general, people in less developed nations don't get enough and qualitative food to realize their full genetic potential. Naturally the same speculation can be done for body weight. In many developed countries, the positive body weight trend is associated with the emergence of overweight and obesity, an extreme pathological outcome of human biological plasticity. Increasing relative body weight and fatness has taken place among populations of North America, Western Europe, Australia and Japan. However, there are still strong class and region-based differences in body weight even in USA, while those for height have mostly disappeared.

4. Conclusions

1. The present study brought first and preliminary findings about andrarche in males and estimated heritability of body height and weight and sexually matured time (menarche and andrarche) in Albanian population.
2. The study revealed that the observed variation of body weight is more influenced by environmental factors than the ones of body height, age at menarche in females and age at andrarche in males.
3. As the growth processes are complex and influenced by different endogenous and exogenous factors, further, deeper and longitudinal research is necessary to be performed in Albanian population, with the objective to identify phenotypic variability in grown patterns, characterized by amplitude and frequency differences in the timing and amaunt of growth events.

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