Title

Association of maternal menarcheal age with anthropometric dimensions and blood pressure in children from Greater Bilbao

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Running title

Mother's menarche and offspring anthropometry and blood pressure

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ABSTRACT

Background: Earlier menarche has been related to shorter height and greater obesity-related anthropometric dimensions and blood pressure in women. Boys and girls with earlier maternal menarcheal age (MMA) have shown greater height and body mass index (BMI) in childhood.

Aim: To analyze associations of menarcheal age with their own and their children's anthropometric dimensions and blood pressure.

Subjects and methods: The sample consisted of 493 women and their children (aged 2-19 years) from Greater Bilbao (Basque Country, Spain). Both generations have information on 19 anthropometric dimensions, blood pressure and socio-demographic characteristics. Linear regressions adjusted for different covariates were used to analyze the associations.

Results: Menarcheal age in women showed the greatest positive associations with iliospinal height and ectomorphy, and negative with BMI, sum of 6 skinfolds, endomorphy and mesomorphy. Boys with earlier MMA had greater body heights and breadths, particularly iliospinal height and biacromial breadth (0.10 z-score/y;$p<0.05$); in girls, earlier MMA predicted greater sitting height, biepicondylar humerus breadth, weight and sum of 4 circumferences (0.07-0.09 z-score/y;$p<0.05$). However, there was some evidence that MMA was positively associated with body heights, ectomorphy and blood pressure in girls aged ≥12.

Conclusion: Children with earlier MMA tend to have greater anthropometric dimensions. Adolescent growth spurt might affect these relationships, at least in girls.

INTRODUCTION

The age at menarche, or the first menstrual period, is an important maturity indicator for the assessment of the developmental status of a pubertal female (Cameron and Nagdee, 1996). A large body of literature has shown that women with earlier age at menarche tend to have smaller stature (Lassek and Gaulin, 2007; Okasha et al., 2001; Sharma et al., 1988) and other body heights and breadths (Gasser et al., 2001; Lassek and Gaulin, 2007; Onland-Moret et al., 2005; Schooling et al., 2008; Sharma et al., 1988) than those who underwent menarche at a later age. In contrast, an inverse association has been reported with obesity-related anthropometric dimensions such as body mass index (BMI) and waist circumference (Feng et al., 2008; Hardy et al., 2006; Kivimaki et al., 2008; Okasha et al., 2001; Pierce and Leon, 2005; Stockl et al., 2011). Blood pressure, one of the most important cardiovascular (CVD) risk factors, has also shown to be higher in girls with earlier menarche compared with later maturing girls (Remsberg et al., 2005), but the evidence is less consistent (Hardy et al., 2006; Kivimaki et al., 2008; Koziel et al., 2001).

Three studies have found that maternal menarcheal age (MMA) is also associated with offspring size (Basso et al., 2010; Min et al., 2014; Ong et al., 2007). In a population based cohort of 6,009 children from the UK earlier MMA predicted greater height, weight, BMI and fat mass index at age 9 (Ong et al., 2007). A study on 31,474 US children showed that those whose mothers had age at menarche before 12 years were taller from age 1 and had higher BMI at ages 7 and 8 compared with those whose mother had menarche at age 15 or later (Basso et al., 2010). Finally, a recent work from South China involving 54,184 women and their offspring observed that children (aged 4-5 years) with earlier MMA were more likely to be overweight than those with late MMA (Min et al., 2014). Based on birth size and growth data, these longitudinal studies additionally indicated that earlier MMA is associated with rapid growth during infancy (Basso et al., 2010; Min et al., 2014; Ong et al., 2007). Shared genetic factors have shown an important role in the association between menarcheal age and obesity phenotypes (Kaprio et al., 1995; Wang et al., 2006) and age at menarche has a strong genetic component with heritability estimates ranging from 53% to 74% (He and Murabito, 2014). It has been thus suggested that the mechanism is likely to be heritable, but other explanations are also possible.

A strength of previous studies (Basso et al., 2010; Min et al., 2014; Ong et al., 2007) is their longitudinal character; however, they are limited to children before puberty and basic anthropometric dimensions. The present sample from Greater Bilbao (Spain) has information on MMA and a large set of anthropometric dimensions and blood pressure both in mothers and their offspring aged 2-19 years. Accordingly, the specific aims of this study are to assess the relationship of age at menarche with anthropometric dimensions and blood pressure in mothers and to determine whether MMA is associated with offspring outcomes.

METHODS

Study sample

The details of the study design and data collection of this cross-sectional sample have been previously reported (Jelenkovic et al., 2010; Jelenkovic et al., 2011). Briefly, the original sample involved 533 nuclear families assessed in education centers from the Greater Bilbao area (Basque Country, Spain) during two academic years (2006-2007 and 2007-2008). Only individuals of European origin were included in the study. The project was approved by the ethics committee of the University of the Basque Country (UPV/EHU). Permission to carry out the study in the education centers was asked from the Basque Government and from the direction of each center. The parents of the participating children provided written informed consent for their own and their children's participation.

During the examination, mothers were asked to recall the date of their first menstrual period as precisely as possible. Of 509 mothers who participated in the study, 493 (26-54 years old at the moment of the study) provided information on their age at menarche and were included in the present study. Of these 493 mothers, only 59 recalled the exact date at their first menstrual period, 143 recalled the month and 114 the season, and the remaining 179 mothers provided the information in complete years. Age at menarche was calculated following the procedure outlined by Wellens and Malina (1990). Briefly, when only month and year were given, the 15th of the month was considered; for individuals who could recall only season and year, the middle of the season was used. Decimal age at menarche was calculated by subtracting the date of birth from the date at menarche. Finally, when subjects only remembered their age at menarche in completed years, a half year was added. The offspring sample (from these 493 mothers) included 409 boys and 374 girls with ages ranging from 2 to 19 years. Some analyzes, however, involved fewer individuals due to missing anthropometric, blood pressure or socioeconomic data. Socio-demographic characteristics were categorized as follows: maternal age at birth (<25, 25-29, 30-34, and ≥35 years for mother's generation, and <30, 30-34 and ≥35 years for offspring generation), parental education (1-university, 2-baccalaureate and vocational training, 3-obligatory school and 4-less than obligatory school for mother's generation and 1-university, 2-baccalaureate, 3-vocational training and 4-obligatory school or less for offspring generation) and number of siblings for offspring generation (1, 2, 3-5).

Anthropometric dimensions and blood pressure

Anthropometric measures included 3 vertical lengths or heights (stature, iliospinal and sitting), 4 breadths (biacromial, bicristal, biepicondylar humerus and femur), 5 circumferences (arm relaxed, arm contracted, waist, hip and calf) and 6 skinfold thicknesses (biceps, triceps, subscapular, suprailiac, abdominal and calf). All measures, whenever possible, were taken on the left side of the body following standard anthropometric techniques. Circumferences were taken to the nearest mm by using Harpenden anthropometric tape (Holtain Ltd). Skinfolds were measured using a Lange caliper (Cambridge Scientific Industries, Cambridge, MD) and the other measurements with Siber-Hegner instruments (GPM, Zurich, Switzerland) precise to 1mm. A digital balance to the nearest 0.1 kg was used to measure body weight. From these anthropometric measures, several derived variables were calculated: the cormic index (sitting height/stature), the relative leg length (iliospinal height/stature), the sum of 4 circumferences (CC4= arm relaxed, waist, hip and calf), the sum of all 6 skinfolds (SF6), body mass index [BMI = weight (kg)/height (m^2)], the waist to hip ratio (WHR = waist circumference / hip circumference) and the trunk to extremity skinfolds ratio [TER = (suprailiac + subscapular + abdominal)/(calf + biceps + triceps)]. Anthropometric somatotype was calculated according to formulas described in Carter and Heath (1990). Systolic (SBP) and diastolic blood pressure (DBP) were measured twice on the left arm of each participant with the Omron M6 (HEM-7001-E) digital device using three different cuff sizes (small, medium and large), as described in Jelenkovic et al. (2010). Only children aged ≥ 4 years were measured for blood pressure. For individuals receiving antihypertensive treatments (5 cases in the present study), the recorded blood pressures were adjusted by adding 10 and 5 mmHg to SBP and DBP, respectively (Cui et al., 2003).

Statistical analysis

MMA showed a normal distribution, and anthropometric dimensions and blood pressure of both generations were natural-log-transformed to achieve normality when needed. Regarding offspring data, a stepwise regression analysis was used to remove the effects of age (age, age^2 and age^3) separately for sons and daughters, followed by z-score transformation (mean: 0; SD: 1).

To study the association of menarcheal age with their own and children's anthropometric dimensions and blood pressure linear regression analyses adjusted for different covariates were performed. Anthropometric dimensions and blood pressure were used as dependent variables, and menarcheal age as a continuous independent variable. In mothers, Model 1 adjusted for age and Model 2 added controls for maternal age at birth and parental education. In case of variables susceptible to change during adulthood, Model 2 was additionally adjusted for own education. When variables were log-transformed variables, the estimated regression coefficients can be interpreted as percentage changes (logX*100= % change). In the offspring generation, we first tested whether there were significant interactions between MMA and children' sex on their anthropometric dimensions and blood pressure. Although statistically significant interactions were observed only for iliospinal height and relative leg length, all variables were analyzed separately by sex in order to detect possible different trends between boys and girls. Regression analyses were adjusted for maternal age, maternal age at birth, parental education and number of siblings in Model 1 and additionally for mother's dimension (mother's height when child´s height was the outcome etc) in Model 2. Standard errors and p-values were adjusted for clustering of siblings within families. All statistical analyses were performed using Stata/IC 12.0 (StataCorp, College Station, Texas, USA).

RESULTS

Characteristics of the sample

Characteristics of mothers and their children are presented in Tables 1 and 2, respectively. For descriptive purpose, mean and standard deviation (SD) of all socio-demographic, anthropometric and blood pressure variables were divided into approximate tertiles of menarcheal age (MMA for offspring). In this sample, mean age at menarche for mother's generation was 13.2 years (Table 1). Women in Tertile 2, compared with those in Tertile 1 and 3, presented lower mean maternal age at birth and a higher proportion of high education; however, the proportion of university educated parents decreased with menarcheal age. Regarding anthropometric dimensions, the greatest differences among tertiles were observed for the somatotype components. Overall, the trend across categories of menarcheal age was positive for linearity related dimensions such as stature, iliospinal height (leg length) and ectomorphy, and negative for variables accounting for the amount of body mass and fat and blood pressure. Descriptive statistics for children according to MMA are presented separately by sex in Table 2. Children of mothers in the oldest menarche tertile showed lower mean z-scores of both heights and obesity-related dimensions compared with children of mothers in the earliest tertile. The greatest differences in relation to MMA were detected between tertiles 1 and 2 in boys and between tertiles 2 and 3 in girls.

Regression analysis

Linear regression analyses assessing the association of menarcheal age with anthropometric dimensions and blood pressure in mothers are presented in Table 3. Regression coefficients were very similar when adjusting for age (Model 1) and additionally for socio-demographic factors (Model 2). The gain in stature (0.35cm/y; $p<0.05$) was attributable to greater leg length (0.38cm/y; $p<0.01$) rather than sitting height (0.005cm/y; $p=0.95$). As expected, cormic index and relative leg length showed opposite associations with menarcheal age (-0.12%/y and 0.11%/y, respectively; $p<0.01$). Significant inverse associations were observed with variables defining the amount of body mass and fat such as BMI (-1.3%/y; $p<0.01$) and SF6 (-3.5mm/y; $p<0.01$); however, menarcheal age was not related to fat distribution (WHR and TER) in this sample. Highly significant associations were detected for the three somatotype components: positive for ectomorphy (0.12/y; p<0.001) and inverse for endomorphy (-0.16/y; p=0.002) and mesomorphy (-0.09/y; p=0.002). Finally, menarcheal age showed a weak negative association with DBP but no effect on SBP.

Associations of MMA with children anthropometric dimensions and blood pressure (expressed as z-scores) are presented in Table 4. As for mothers, adjustment for socio-demographic characteristics (Model 1) showed similar results to the age-adjusted model (available upon request). In contrast to the observations in mothers, significant associations between MMA and children anthropometry were all negative. The greatest associations were observed for body heights, particularly iliospinal height (-0.10 z-score/y; p<0.01), and body breadths (except for biepicondylar femur breadth) in boys, and for sitting height, biepicondylar humerus breadth, weight and CC4 in girls (from -0.07 to -0.09 z-score/y; p<0.05). In order to assess whether there was an association between MMA and offspring variables beyond that due to correlation with mother's variables, Model 1 was additionally adjusted for mother's anthropometry/blood pressure (Model 2). This adjustment strengthened the associations with stature, iliospinal height and ectomorphy in boys and the three vertical lengths in girls, but attenuated those with sitting height and bicristal breadth in boys and with obesity-related dimensions in girls.

Finally, we aimed to ascertain whether the associations are affected by adolescent growth spurt (Appendix Table). Since the peak height velocity (PHV) is approximately 14 years in boys and 12 years in girls (Marshall and Tanner, 1969; Marshall and Tanner, 1970), children were divided into two subsamples: <14 years and ≥14 years in boys (Nmax 363 and 46, respectively) and <12 years and ≥12 years in girls (Nmax 296 and 78, respectively). Highlighting differences between ages were observed for body heights in girls, in such a way that MMA showed negative associations in those aged <12 years and positive in those aged ≥12 years. Important differences between ages were also detected for SF6 in boys, the somatotype components in girls and for blood pressure in both sexes. However, and as expected because of the reduced number of individuals aged ≥14/12 years, these associations were not statistically significant. Only the positive association observed between MMA and SBP in girls (0.16 and 0.18 z-score before and after adjustment for mother's SBP, respectively; $p<0.01$) reached statistical significance.

DISCUSSION

This sample from Greater Bilbao showed that mother's age at menarche is associated not only with her anthropometric dimensions and blood pressure, but is also related to her offspring outcomes, even after adjustment for maternal dimensions. Although the effects were in general small, our findings support previous observations of greater body size in children with earlier MMA.

In agreement with several studies, we observed that earlier menarche was associated with shorter stature (Lassek and Gaulin, 2007; Okasha et al., 2001; Sharma et al., 1988) and leg length in women (Gasser et al., 2001; Hardy et al., 2006; Onland-Moret et al., 2005; Schooling et al., 2008). Based on the magnitude of the associations, the increase in height by menarcheal age appeared to be largely explained by the increase in leg length, which has been found to be the component of height most strongly associated with CVD risk (Gunnell et al., 2003; Smith et al., 2001). Our findings also support the intergenerational association between earlier MMA and taller stature in offspring previously reported (Basso et al., 2010; Min et al., 2014; Ong et al., 2007). Additional adjustment for maternal height strengthened the associations, indicating that mothers with earlier age at menarche were shorter than mothers with later age at menarche, while their children were on average taller in this sample (the majority of them aged below 12 years). These previous works showed that in children up to 9 years patterns are similar in boys and girls (Basso et al., 2010; Ong et al., 2007). In the present study, however, the association between MMA and height showed a positive trend (not statistically significant because of small sample size) in girls aged ≥12 years, but not in boys aged ≥14 years. It has been suggested that earlier age at menarche may be a transgenerational marker of a faster growth tempo, characterized by rapid weight gain and growth during infancy, and leading to taller childhood stature, but likely earlier maturation and therefore shorter adult stature (Basso et al., 2010; Ong et al., 2007); the positive trend observed for girls aged ≥12 years in our study supports this hypothesis. In line with observations in mothers, in girls aged ≥12 years the association of MMA was greater with leg length than with stature. During prepubertal years growth of the long bones is more rapid than trunk growth whereas during the pubertal growth spurt, growth velocity of the trunk accelerates to exceed that of the long bones (Seeman, 2001). An earlier age at menarche allowing less time for the pubertal growth spurt and thus shorter leg size (Gasser et al., 2001) is concordant with our findings. An association between earlier puberty and shorter legs has also been observed in men (Lorentzon et al., 2011). It has been suggested that adult leg length does not represent the same early life exposures in men and women (Schooling et al., 2010). However, the number of boys aged ≥14 years in our sample is not large enough to ascertain whether the relationship between MMA and leg length differ between sexes.

Earlier age at menarche has also been associated with body breadths (Lassek and Gaulin, 2007 ; Sharma et al., 1988), which was not observed in the present study. The inverse relationship between menarcheal age and biepicondylar femur breadth found in women might be explained by the overlying soft-tissue rather than by the bone size. Accordingly, the positive association observed for biiliac breadth in the NHANES III sample was suggested to be mediated by pelvic size and not by the portion of hip circumference external to the bony pelvis (Lassek and Gaulin, 2007). MMA was negatively associated with biacromial, bicristal and biepicondylar humerus breadths in offspring but showed a trend towards a positive association with biacromial breadth in girls aged ≥12 years, as observed for vertical lengths.

Regarding obesity-related dimensions, the greater BMI observed in women with earlier menarche is in agreement with several studies (Feng et al., 2008; Hardy et al., 2006; Kivimaki et al., 2008; Okasha et al., 2001; Pierce and Leon, 2005; Stockl et al., 2011). Similar to observations for total and abdominal fat (Feng et al., 2008), subcutaneous fat (SF6) showed a negative association in our sample. In contrast to other studies (Feng et al., 2008; Kivimaki et al., 2008; Stockl et al., 2011) age at menarche was not associated with waist circumference; however, a lack of association with WHR, a measure of fat distribution, was also observed in 53 years women (Hardy et al., 2006). Concerning the association with offspring outcomes, it has been previously shown that earlier MMA predicted greater weight, BMI and fat mass index in childhood (Basso et al., 2010; Min et al., 2014; Ong et al., 2007). In the present sample, a trend towards a negative relationship with dimensions accounting for the amount of body mass and fat was also detected, particularly for girls; however, very few associations reached statistical significance and disappeared after adjustment for mothers´ variables. Anthropometric somatotype showed the strongest associations in mothers. A negative trend of menarcheal age with mesomorphy and positive with ectomorphy, although not statistically significant, was also observed in female junior rowers (Claessens et al., 2003). In the offspring generation, MMA also showed important associations with somatotype components in girls aged ≥12 years. The direction of the relationships reflects those in mothers, suggesting again the relevance of adolescent growth spurt in the association between MMA and offspring outcomes, at least in girls. Finally, the stronger associations observed with somatotype components in both generations highlight the validity of using anthropometric somatotype in epidemiological research.

The relationship between menarcheal age and blood pressure has shown more inconsistent results (Hardy et al., 2006; Kivimaki et al., 2008; Koziel et al., 2001; Remsberg et al., 2005). The negative association observed with DBP in women, but not with SBP, agrees with the observations in 14 years old girls (Koziel et al., 2001); however, Remsberg et al. (2005) reported that both SBP and DBP were elevated in early maturing girls, independent of body composition. To our knowledge, this is the first study analyzing the relationship between MMA and offspring blood pressure. As for several anthropometric dimensions, the associations were considerably stronger in girls aged ≥12 years and the positive associations observed for SBP and DBP (not statistically significant for DPB) strengthened after adjustment for maternal blood pressure. Hardy et al. (2006) found that BDP was highest in the latest menarche group (after adjustment for body size). These authors speculated that since earlier menarche in women is associated with an increased lifetime exposure to oestrogen, if this increased estrogen exposure is also cardioprotective, then it could explain these findings (Hardy et al., 2006); however, the mechanisms remains unknown.

It was not the goal of this study to determine the mechanism by which MMA is associated with anthropometric dimensions and blood pressure in offspring. However, the socio-demographic factors considered did not explain the relationships of interest, suggesting that these factors are unlikely to be the underlying mechanisms. Adjusting the associations for mother's dimensions only attenuated some of the associations and thus the link between MMA and offspring outcomes is unlikely to be confounded by mother's dimensions. As suggested by other authors (Basso et al., 2010; Min et al., 2014; Ong et al., 2007), the intergenerational link of MMA with anthropometry and blood pressure might be explained by genetic factors transmitted to the offspring from the mother. Menarcheal age and obesity phenotypes have genetic factors in common (Kaprio et al., 1995; Wang et al., 2006) and age at menarche has shown a strong genetic component (He and Murabito, 2014). It is, however, also possible that this intergenerational association is not solely genetically determined, and other non-genetic characteristics associated with MMA, such as nutrition, also influence their children's anthropometric dimensions and blood pressure.

A recent study showed that gestational weight gain modified the association between earlier MMA and offspring growth and overweight, which shed some light into in-utero modifications of these intergenerational relationships (Min et al., 2014).

This study has several strengths. The main advantage is the information on a large set of anthropometric variables and blood pressure for both mothers and their children aged up to 19 years. In addition, anthropometric data are based on objectives measures taken by the same researcher (AJ). Another strong point is the availability of information on demographic and socioeconomic factors. But our study has some limitations, as well. The main limitation of the study is the relatively small sample size, creating challenges in evaluating statistical significance for some of the associations of interest. Moreover, we did not have information on children's birth weight nor growth during infancy and not all ages were equally represented. It is important to note that mean age at PHV reported in Marshal and Tanner (1969, 1970) was based on data collected in the 1950s and 1960s and evidence suggests that age at PHV thereafter declined both in boys and girls (Hermanussen, 2013); these changes in mean age at PHV were in general small and population dependent. However, this slight decline in mean age at PHV is unlikely to affect the observed differences in the association between MMA and offspring outcomes before and after PHV. Finally, the findings from association studies cannot establish causal relationships and we can only speculate about the biological mechanisms behind the observed associations.

Regardless of the underlying mechanism, our study illustrates the existence of an association of MMA with anthropometric dimensions and blood pressure in offspring. Although the magnitude is in general small, we show that children of mothers with earlier menarche tend to have greater body heights and breadths and obesity-related dimensions. Finally, our findings suggest that adolescent growth spurt might affect the relationship between MMA and children outcomes, at least in girls. These findings have theoretical significance and might help to shed light on the underlying biological mechanisms in future research. Large samples of pre- and postpubertal children are needed to determine whether the intergenerational associations between MMA and offspring CVD risk factors change after puberty in both sexes.

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DECLARATION OF INTEREST

The authors report no declarations of interest.

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Table 1. Descriptive statistics for mothers' characteristics in relation to their self-reported age at menarche

	N	Total	By age at menarche (years)		
			<12 (N=114)	12-13.9 (N=236)	≥14 (N=143)
Age at menarche (years)	493	13.2(1.5)	11.2(0.7)	13.0(0.6)	15.0(1.0)
Age (years)	493	41.8(4.8)	42.4(4.9)	41.6(4.6)	41.5(4.9)
Maternal age at birth (years)	487	29.5(5.5)	29.6(5.4)	29.0(5.3)	30.2(5.9)
High education father (%)	485	21.9	27.0	21.0	19.1
High education mother (%)	486	9.3	10.8	10.3	6.4
High education subject (%)	493	56.8	57.9	62.3	46.9
Stature (cm)	493	160.9(5.7)	160.4(5.7)	160.9(5.8)	161.3(5.5)
Sitting H (cm)	490	85.8(2.9)	85.9(3.0)	85.9(3.0)	85.7(2.8)
Iliospinal H (cm)	492	89.7(4.3)	89.2(4.4)	89.7(4.4)	90.2(4.1)
Cormic index *100	489	53.4(1.2)	53.6(1.3)	53.4(1.2)	53.1(1.1)
Relative leg length *100	492	55.7(1.4)	55.6(1.3)	55.7(1.3)	55.9(1.4)
Biacromial Br (cm)	493	36.2(1.4)	36.0(1.2)	36.2(1.4)	36.3(1.5)
Bicristal Br (cm)	483	30.0(2.0)	30.1(2.0)	30.0(2.1)	30.0(2.0)
Biepicondylar humerus Br (cm)	493	5.90(0.3)	5.88(0.3)	5.91(0.3)	5.91(0.3)
Biepicondylar femur Br (cm)	493	8.83(0.4)	8.88(0.4)	8.85(0.4)	8.75(0.5)
Weight (kg)	483	61.1(8.8)	62.4(8.3)	61.1(8.2)	60.0(9.9)
Waist C (cm)	482	75.5(7.7)	76.9(8.3)	75.3(6.9)	74.9(8.3)
BMI (kg/m^2)	483	23.6(3.2)	24.3(3.3)	23.6(3.0)	23.0 (3.5)
CC4 (cm)	482	237.8(17.7)	240.9(17.2)	237.8(16.6)	235.3(19.6)
SF6 (mm)	482	125.0(42.0)	134.0(46.3)	125.5(36.5)	116.9(45.5)
WHR *100	482	76.7(5.2)	77.3(6.1)	76.4(4.7)	76.8(5.0)
TER*100	482	106.8(30.1)	113.8(35.2)	105.9(28.6)	102.8(27.4)
Endomorphy	482	6.01(1.7)	6.40(1.9)	6.10(1.5)	5.62(1.9)
Mesomorphy	483	4.21(1.0)	4.39(1.0)	4.24(1.0)	4.03(1.0)
Ectomorphy	482	1.64(1.0)	1.41(1.0)	1.62(1.0)	1.87(1.0)
SBP (mmHg)	483	114.9(12.8)	115.2(12.1)	115.0(12.0)	114.3(14.6)
DBP (mmHg)	482	72.1(8.6)	73.0(8.3)	72.4(8.4)	70.9(9.3)

Data are given in mean (standard deviation). N, number of individuals; H, height; Br, breadth; C, circumference; SK, skinfold; BMI, body mass index; SF6, sum of 6 skinfolds; WHR, waist to hip ratio; TER, Trunk to extremity skinfold ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 2. Descriptive statistics for offspring generation in relation to their mother's age at menarche

	Sons				Daughters			
	N	<12 (N=100)	12 -13.9 (N=203)	≥14 (N=106)	N	<12 (N=82)	12 -13.9 (N=175)	≥14 (N=106)
Age (years)	409	9.7(3.9)	8.7(3.8)	8.7(3.9)	374	8.6(4.0)	9.0(4.0)	9.0(3.7)
Maternal age at birth (years)	409	32.4(3.5)	32.4(3.7)	32.7(4.3)	374	33.0(3.9)	32.6(3.5)	32.3(4.2)
Number of siblings	409	2.1(0.8)	2.1(0.6)	1.9(0.5)	374	2.2(0.8)	2.1(0.6)	2.0(0.6)
High education father (%)	401	50.0	64.0	44.7	369	50.0	46.2	43.1
High education mother (%)	409	58	72.9	50.9	374	65.9	61.1	50.4
Stature z-score	409	0.30(1.13)	-0.09(0.93)	-0.12(0.94)	374	0.10(0.89)	0.07(1.02)	-0.11(1.01)
Sitting H z-score	408	0.25(1.10)	-0.07(0.95)	-0.08(0.94)	374	0.16(0.92)	0.05(1.04)	-0.14(0.99)
Iliospinal H z-score	408	0.32(1.10)	-0.09(0.94)	-0.14(0.97)	374	0.03(0.99)	0.06(1.01)	-0.08(0.98)
Cormic index z-score	407	-0.06(1.03)	0.01(0.95)	0.08(1.0)	371	0.11(1.08)	-0.04(1.01)	0.01(0.96)
Relative leg length z-score	405	0.15(1.01)	-0.03(0.93)	-0.12(1.18)	373	-0.13(1.11)	0.02(1.02)	0.02(0.88)
Biacromial Br z-score	409	0.21(1.23)	-0.02(0.92)	-0.19(0.88)	374	0.08(0.97)	0.04(0.98)	-0.12(1.04)
Bicristal Br z-score	407	0.17(1.18)	-0.01(0.93)	-0.11(0.99)	373	0.06(0.88)	0.12(1.01)	-0.19(1.01)
Biepicondylar humerus Br z-score	408	0.19(1.11)	-0.02(0.98)	-0.06(0.93)	374	0.11(0.88)	0.10(0.97)	-0.25(1.08)
Biepicondylar femur Br z-score	408	0.10(1.11)	-0.01(0.95)	-0.08(1.02)	374	0.11(0.96)	0.06(1.01)	-0.16(0.99)
Weight z-score	409	0.19(1.15)	-0.02(0.96)	-0.10(0.95)	374	0.08(0.95)	0.14(0.97)	-0.26(1.02)
Waist C z-score	409	0.09(1.19)	-0.01(0.96)	-0.06(0.96)	373	0.01(0.93)	0.13(0.95)	-0.25(1.02)
BMI z-score	409	0.02(1.14)	0.04(0.98)	-0.04(0.97)	374	0.02(1.00)	0.15(0.96)	-0.26(1.00)
CC4 z-score	400	0.13(1.17)	-0.01(0.97)	-0.08(0.94)	371	0.08(0.94)	0.13(0.95)	-0.26(1.03)
SF6 z-score	398	0.03(1.04)	-0.02(1.02)	0.02(0.91)	372	0.03(0.93)	0.12(0.97)	-0.22(1.03)
WHR z-score	400	-0.19(0.87)	0.05(1.03)	0.03(1.03)	371	-0.18(0.89)	0.01(1.05)	0.02(0.94)
TER z-score	398	0.11(1.03)	-0.05(0.98)	-0.03(1.01)	372	-0.06(0.92)	0.05(1.02)	-0.11(0.99)
Endomorphy z-score	399	-0.01(1.02)	-0.00(1.05)	0.03(0.89)	373	-0.01(0.92)	0.11(1.01)	-0.21(1.00)
Mesomorphy z-score	377	-0.17(1.03)	0.13(1.00)	0.02(1.00)	347	0.06(1.04)	0.03(0.98)	-0.17(0.98)
Ectomorphy z-score	409	0.13(1.10)	-0.08(0.97)	-0.03(0.99)	373	0.03(1.02)	-0.11(0.98)	0.20(0.98)
SBP z-score	303	0.02(1.10)	0.05(0.92)	-0.12(1.04)	271	-0.16(1.00)	-0.00(0.97)	0.07(1.01)
DBP z-score	302	-0.00(1.08)	0.03(0.94)	0.02(1.04)	272	-0.15(1.01)	0.15(1.03)	-0.14(0.92)

Data are given in mean (standard deviation). N, number of individuals; H, height; Br, breadth; C, circumference; SK, skinfold; BMI, body mass index; SF6, sum of 6 skinfolds; WHR, waist to hip ratio; TER, Trunk to extremity skinfold ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 3. Regression coefficients for the association of menarcheal age with anthropometrics and blood pressure in mothers.

	Model 1		Model 2	
Traits	B(CI)	P-value	B(CI)	P-value
Stature (cm)	0.342(0.018,0.667)	0.039	0.353(0.020,0.687)	0.038
Sitting H (cm)	0.008(-0.161,0.177)	0.923	0.005(-0.170,0.180)	0.952
Iliospinal H (cm)	0.363(0.116,0.610)	0.004	0.381(0.127,0.635)	0.003
Cormic index*100	-0.116(-0.185,-0.048)	0.001	-0.124(-0.196,-0.052)	0.001
Relative leg length*100	0.101(0.024,0.179)	0.010	0.108(0.027,0.189)	0.009
Biacromial Br (cm)	0.057(-0.022,0.136)	0.154	0.062(-0.021,0.145)	0.143
Bicristal Br (cm)	0.027(-0.087,0.141)	0.642	0.047(-0.073,0.166)	0.442
[a]Biepicondylar humerus Br	0.001(-0.002,0.004)	0.606	0.001(-0.002,0.004)	0.686
[a]Biepicondylar femur Br	-0.003(-0.006,-0.000)	0.033	-0.003(-0.006,-0.000)	0.038
[a]Weight	-0.008(-0.016,0.000)	0.057	-0.008(-0.017,0.000)	0.061
[a]Waist C	-0.004(-0.009,0.002)	0.200	-0.004(-0.010,0.002)	0.193
[a]BMI	-0.012(-0.020,-0.005)	0.001	-0.013(-0.021,-0.005)	0.001
[a]CC4	-0.004(-0.008,-0.000)	0.048	-0.005(-0.009,-0.000)	0.041
SF6 (mm)	-3.623(-6.043,-1.202)	0.003	-3.463(-5.980,-0.945)	0.007
[a]WHR	0.000(-0.003,0.004)	0.854	-0.001(-0.003,0.005)	0.758
[a]TER	-0.015(-0.031,0.001)	0.069	-0.013(-0.030,0.004)	0.134
Endomorphy	-0.167(-0.267,-0.068)	0.001	-0.162(-0.265,-0.059)	0.002
Mesomorphy	-0.088(-0.145,-0.030)	0.003	-0.092(0.151,-0.032)	0.002
Ectomorphy	0.115(0.058,0.172)	<0.001	0.123(0.065,0.181)	<0.001
[a]SBP	-0.002(-0.008,0.004)	0.558	-0.002(-0.008,0.005)	0.587
[a]DBP	-0.008(-0.015,-0.001)	0.023	-0.007(-0.015,-0.000)	0.043

B: Unstandardized regression coefficient; CI: Confidence interval; H, height; Br, breadth; C, circumference; SK, skinfold; BMI, body mass index; SF6, sum of 6 skinfolds; WHR, waist to hip ratio; TER, Trunk to extremity skinfold ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure.
[a]log-transformed. Estimated regression coefficients can be interpreted as percentage changes (logX*100= % change).
Model 1. Adjusted for age
Model 2. Additionally adjusted for maternal age at birth, parental education. In case of variables susceptible to change during adulthood-from weight to DBP in the list-, model 2 was additionally adjusted for own education.

Table 4. Standardized regression coefficients for the association of maternal menarcheal age with anthropometrics and blood pressure in offspring

	Model 1				Model 2			
	Sons		Daughters		Sons		Daughters	
Traits	β	P-value	β	P-value	β	P-value	β	P-value
Stature	-0.090	0.012	-0.061	0.066	-0.104	0.005	-0.095	0.001
Sitting H	-0.072	0.055	-0.070	0.028	-0.062	0.125	-0.073	0.010
Iliospinal H	-0.102	0.007	-0.022	0.511	-0.140	<0.001	-0.057	0.047
Cormic index	0.032	0.425	-0.015	0.636	0.058	0.169	0.017	0.582
Relative leg length	-0.059	0.182	0.063	0.050	-0.085	0.058	0.054	0.072
Biacromial Br	-0.099	0.013	-0.040	0.265	-0.100	0.010	-0.050	0.146
Bicristal Br	-0.080	0.036	-0.056	0.115	-0.048	0.178	-0.065	0.049
Biepicondylar humerus Br	-0.080	0.030	-0.090	0.010	-0.088	0.005	-0.088	0.006
Biepicondylar femur Br	-0.037	0.350	-0.058	0.064	-0.008	0.823	-0.042	0.151
Weight	-0.067	0.065	-0.079	0.022	-0.019	0.599	-0.063	0.069
Waist C	-0.044	0.279	-0.058	0.095	-0.009	0.824	-0.051	0.149
BMI	-0.025	0.501	-0.060	0.076	0.026	0.500	-0.040	0.282
CC4	-0.060	0.115	-0.074	0.029	-0.016	0.662	-0.062	0.075
SF6	-0.005	0.906	-0.064	0.073	0.033	0.410	-0.044	0.229
WHR	0.043	0.288	0.047	0.122	0.042	0.333	0.041	0.173
TER	-0.042	0.311	-0.027	0.402	-0.003	0.937	-0.019	0.535
Endomorphy	0.001	0.989	-0.053	0.118	0.039	0.330	-0.030	0.382
Mesomorphy	0.021	0.575	-0.034	0.262	0.054	0.160	-0.006	0.853
Ectomorphy	-0.034	0.381	0.037	0.269	-0.084	0.041	0.008	0.829
SBP	-0.041	0.340	0.052	0.159	-0.047	0.292	0.056	0.138
DBP	-0.011	0.796	-0.011	0.803	-0.017	0.705	0.010	0.809

β: Standardized regression coefficient; H, height; Br, breadth; C, circumference; SK, skinfold; BMI, body mass index; SF6, sum of 6 skinfolds; WHR, waist to hip ratio; TER, Trunk to extremity skinfold ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Model 1. Adjusted for maternal age, maternal age at birth, parental education and number of siblings.

Model 2. Model 1 additionally adjusted for mother’s trait.