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Sex dimorphism in growth

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Summary. While there is agreement that sex differences in height are small up to the onset of the pubertal spurt in girls, there has been some debate about the question of which, and to what extent, various growth phases contribute to the average adult sex difference of about 13 cm. There has been no consistent agreement between authors as to what extent this difference is due to the late onset of the pubertal spurt (PS) for boys and to what extent it is due to their more intense PS. In this paper, we investigate this question for the variables height, sitting and leg height, arm length, bihumeral and biiliac width. Biiliac width is a special case since both sexes have roughly the same adult size, but girls still have a shorter growing period. The gains for boys, when compared to girls, show a very different pattern across variables: for the legs, the additional growth due to the later spurt is responsible for most of the adult sex difference (64%). On the other hand, for bihumeral width and sitting height, the more intense PS contributes almost 50% to the adult sex difference. An analysis across variables indicates that increments from 1.5 to 6 years largely compensate for deviations in infant morphology from adult morphology.

1. Introduction

It is common knowledge that adult males are larger on average in size than females in most physical dimensions, biiliac width being an exception. There has been some debate—even for height, the variable most frequently studied—as to how and when this sex difference arises (see Hauspie 1980 for an excellent review). There is general agreement that only small differences arise prior to the mean age of onset of the pubertal spurt (PS) for girls. The later onset of the pubertal spurt for boys has been viewed as the major contributing factor to sex difference for height by some (e.g. Tanner, Whitehouse, Marubini and Resele 1976), while others have noted a more equal contribution of the later onset and the greater PS of boys (e.g. Largo, Gasser, Prader *et al.* 1978). Hauspie, Das, Preece *et al.* (1985) studied sexual dimorphism for height, sitting height, biacromial and biiliac width in samples of children from Britain and West Bengal. (In our comparisons we concentrate on the British sample.) This study was based on the Preece-Baines model and the decomposition of the total growth period into a prepubertal period, a delay due to the later spurt for boys and an adolescent period. Koziel, Hauspie and Susanne (1995) undertook a similar analysis for height and sitting height of Belgian children. In both analyses, the delay explained a much larger portion of adult sex difference than adolescence and more so in the British sample than in the Belgian sample.

This note attempts to clarify this issue by studying the variables standing height, leg and sitting height, arm length, and bihumeral and biiliac width. Based on individual curve fitting for distance (size achieved), velocity and acceleration, a detailed analysis of the prepubertal and the adolescent period has been undertaken (see also Sheehy, Gasser, Molinari and Largo 1999). The analysis was not based on some parametric model but rather on kernel estimators, a non-parametric curve fitting

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technique (Gasser, Müller, Köhler *et al.* 1984b). The prepubertal growth has been subdivided into a contribution till one month (mainly intrauterine growth), an increment from one month till 1.5 years, one from 1.5 to 6 years and one from 6 years to the onset of the PS for girls. Adolescent growth has been subdivided into an increment associated with the basic prepubertal velocity level and an increment arising from the PS (we will call these two increments, 'the increment due to level' and 'the increment due to spurt' respectively, although this is only an operational definition and not a truly biological one).

2. Subjects and methods

The samples analysed, and the measurement techniques have been described in full detail in earlier papers (Gasser, Kneip, Binding *et al.* 1991a, Gasser, Kneip, Ziegler *et al.* 1991b), and we keep the description short here.

2.1. Subjects

In an internationally coordinated study (Falkner 1960), participation of a representative sample of 160 girls and 161 boys from urban Zurich was achieved. Children who missed more than two visits, or two successive visits, and children with a disease affecting growth were excluded from this analysis, leading to a final sample of 112 girls and 120 boys.

2.2. Measurements

Visits to the pediatric clinic were planned at 1, 3, 6, 9, 12, 18 and 24 months and then annually. At age 9 for girls and age 10 for boys measurements were done half-yearly until height growth was less than 0.5 cm in two years. Annual measurements usually continued until 20 years, but at least until 18 years. The exact timings of the measurements are used in our analysis.

Linear measurements were taken with Harpenden instruments to the nearest millimetre, except for arm length which was measured with a tape and then unfortunately rounded to cm. Leg height was obtained as standing height minus sitting height. Biiliac and bihumeral width were measured with calipers. Post-hoc it is clear that biacromial width would have been preferable to bihumeral width, since it reflects more clearly skeletal growth.

2.3. Statistical methods

Characteristics of the PS were determined by individual curve fitting of distance (size achieved), velocity and acceleration via kernel estimators, a refined way of smoothing the data. As in Gasser, Köhler, Müller *et al.* (1984a), the following ages have been determined: age of minimal velocity before the PS ('onset of the PS' =T6), age of maximal acceleration (=T7), of peak velocity (=T8) and of maximal deceleration (=T9). The choice of smoothing parameter (the bandwidth) has been made as in Sheehy *et al.* (1999).

Based on the individual fitted curves, increments in different phases of growth have been determined: the prepubertal period from 1 month till the onset of the PS has been subdivided at ages 1.5 and 6 years. The demarcation at 1.5 years has been made since at that age rapid postnatal growth begins to become more steady; this seems to be associated with the fact that the transition from intrauterine to extra-uterine growth is terminated between 1 and $1\frac{1}{2}$ years. We chose 6 years as the next demarcation, since it subdivides about equally the period from 1.5 years to the onset

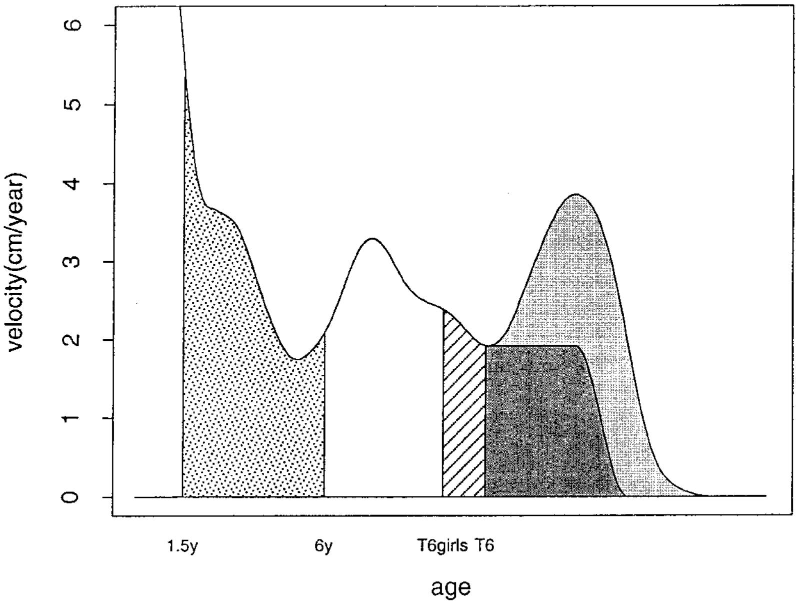

Figure 1. Illustration of the decomposition into increments (example: velocity curve for sitting height for a boy). Increments from 1 month to 1.5 years (white), from 1.5 to 6 years (dotted), from 6 years to T6girls (white), from T6girls to T6 (striped), for the adolescent component due to the basic velocity level (dark grey) and for adolescent component due to the spurt (light grey).

of the PS. Note that the increment in a given interval is equivalent to the area under the velocity curve in that interval. For boys the increment between 6 years and T6 has been subdivided into two parts; the first increment is that occurring between 6 years and the average age of onset of puberty for girls (T6girls) and the second is that occurring between T6girls and the individual T6 for a given boy. For girls we consider only the full increment occurring from 6 years to T6. Growth during adolescence, after T6, has been subdivided in Largo *et al.* (1978) into an increment due to the pubertal peak and one associated with the baseline velocity. The latter was obtained by continuing the velocity beyond T6 as a constant. This does not correspond well with the current state of endocrinological knowledge and for this reason we decided for a different subdivision here as depicted in figure 1.

It is clear that adolescent growth consists on the one hand of extra growth due to pubertal sex steroids, leading to a pubertal velocity peak, and on the other hand, of a growth component which is a continuation of prepubertal growth. Some biological evidence is provided by the fact that prepubertal growth continues till age 20, or even beyond, in conditions where puberty does not occur. While puberty initiates further growth, it also triggers the switch-off of prepubertal and pubertal growth. There is some arbitrariness in postulating a switch-off function: we choose to let prepubertal growth velocity be constant from T6 till T8 (as in Largo *et al.* 1978). At T8 acceleration becomes negative and we, therefore, postulate a decrease of prepubertal growth velocity in the form of a sinusoidal curve. A similar decomposition was considered in a model by Stützle, Gasser, Molinari *et al.* (1980). The rationale for this decomposition will be discussed in more detail in a forthcoming paper. It is, however, important to note that changing the definition of the switch-off function

Table 1. Means and standard deviations for adult size (in cm) and average percentage adult sex difference (100 × mean (m-f)/mean (m)).

Sex		Bihum. W.	Biiliac W.	Sit. H.	Stand. H.	Leg H.	Arm L.
m	x̄	42.3	27.9	93.7	178.0	84.4	79.9
f		37.7	27.7	88.0	165.0	77.1	72.9
m	s	1.8	1.7	3.4	7.0	4.6	3.5
f		1.6	1.7	2.8	5.9	4.0	3.1
Sex diff.	x̄	4.5	0.2	5.8	13.1	7.3	7.0
% Sex diff.	x̄	10.7	0.7	6.2	7.3	8.6	8.7

does not qualitatively change results. Thus, after the onset of the PS, at T6, we have an increment due to the spurt and one due to the prepubertal level.

To assess the statistical significance of sex differences in adult size and in increments (in cm) in various growth phases, we used two sample t-tests. In the case of relative increments (phase increment/adult size) it is of interest to analyse differences across variables in addition to sex differences, and also to check if sex differences are homogeneous across variables. A repeated measures ANOVA with Greenhouse-Geisser correction was used, as in Sheehy *et al.* (1999).

3. Results

Means and standard deviations for adult size are given in table 1. There is a negligible sex difference for biiliac width; for the other variables the adult size for males is from 6.2% (for sitting height) to 10.7% (for bihumeral width) larger than that for females. All differences are statistically highly significant except for biiliac width. The percentage difference has been computed as mean of males minus mean of females divided by the mean of males (×100).

The means and standard deviations of successive increments are tabulated in table 2. The periods chosen are from conception until 1 month, from 1 month until 1.5 years, from 1.5 to 6 years, from 6 years to the average age of onset of the PS for girls (T6girls), from T6girls to T6, the increment due to the baseline velocity level during the PS and the increment due to pubertal growth. For the girls, entries in the columns headed 6 years to T6girls correspond to increments occurring between 6 years and the individual T6 for a given girl, and the columns headed T6girls to T6 are zero.

Sex differences until the onset of the PS for girls (T6girls) are small or negligible, but some reach statistical significance: for sitting height boys have significantly larger values till 1.5 years, and the same is true for arms. The larger values for biiliac width for girls from 1.5 years to T6girls are also statistically significant. The increment due to the spurt is significantly larger for boys than for girls, except for biiliac width. Sex differences due to the level are significant only for bihumeral and biiliac width and arms.

The results for relative increments are given in table 3 and figure 2 (except for the phase T6 to T6girls). The repeated measures ANOVA for a given increment considers the factors sex and variable and the interaction of sex with variable. Let us first comment on sex differences: As we have seen in table 2, prepubertal sex differences in absolute increments are small. Due to the smaller adult size (except for biiliac width), relative increments have to be larger for girls. Notable is a large relative increment in

Table 2. Means and standard deviations of increments x̄ (s) (in cm).

Variable		1 month x̄	1 month (s)	1 month to 1.5y x̄	1 month to 1.5y (s)	1.5y to 6y x̄	1.5y to 6y (s)	6y to T6girls x̄	6y to T6girls (s)
Bihum. W.	m	12.3	(0.7)	8.3	(1.0)	6.1	(0.9)	3.8	(0.6)
	f	12.3	(0.7)	8.1	(1.0)	6.1	(0.8)	3.8	(1.1)
Biiliac W.	m	8.8	(0.5)	5.1	(0.7)	4.8	(0.8)	2.5	(0.4)
	f	8.6	(0.4)	5.0	(0.6)	5.1	(0.7)	2.7	(0.8)
Sit. H.	m	33.7	(1.5)	15.7	(1.5)	15.4	(1.5)	9.2	(1.1)
	f	33.1	(1.3)	14.9	(1.6)	15.8	(1.7)	9.2	(2.2)
Stand. H.	m	53.1	(2.3)	29.0	(2.2)	35.4	(2.8)	21.5	(1.9)
	f	52.3	(1.9)	27.8	(2.1)	36.0	(2.6)	21.2	(4.9)
Leg H.	m	19.4	(1.3)	13.3	(1.4)	20.1	(1.9)	11.1	(1.4)
	f	19.2	(1.2)	12.9	(1.5)	20.2	(1.7)	10.8	(4.1)
Arm L.	m	21.6	(1.5)	12.6	(1.4)	16.7	(1.6)	9.5	(1.0)
	f	21.0	(1.4)	11.9	(1.3)	16.7	(1.4)	9.4	(2.6)

Variable		T6girls to T6 x̄	T6girls to T6 (s)	PS level x̄	PS level (s)	PS spurt x̄	PS spurt (s)
Bihum. W.	m	0.9	(1.4)	4.0	(1.2)	6.9	(1.9)
	f	0.0	(0.0)	3.0	(1.1)	4.7	(1.4)
Biiliac W.	m	1.0	(0.9)	2.6	(0.6)	3.2	(0.8)
	f	0.0	(0.0)	2.9	(0.8)	3.4	(1.0)
Sit. H.	m	2.5	(2.2)	6.5	(2.0)	10.9	(2.0)
	f	0.0	(0.0)	7.0	(2.0)	8.1	(2.0)
Stand. H.	m	6.3	(5.2)	16.8	(3.4)	15.9	(2.6)
	f	0.0	(0.0)	16.3	(3.4)	11.4	(2.4)
Leg H.	m	4.6	(3.6)	9.6	(2.5)	6.4	(1.6)
	f	0.0	(0.0)	8.9	(2.4)	5.1	(1.9)
Arm L.	m	2.5	(2.8)	8.2	(1.8)	8.9	(2.2)
	f	0.0	(0.0)	7.6	(1.8)	6.4	(1.6)

biiliac width for girls, compared to boys, from 1.5 to 6 years (figure 2). Sex differences are overall small for the level of the PS, and in fact statistically not significant. The relative increment due to the spurt demonstrates large sex differences: boys gain more in all variables except for biiliac width.

Patterns of relative increments across variables reflect deviations and changes from adult morphology. Figure 2 is helpful in this respect since a constant line indicates that different parts of the body are growing in proportion to adult morphology. At one month tremendous differences between variables are seen, with less than one-fourth of adult size reached for legs and more than 36% for sitting height. Interestingly, the pattern of relative increments from 1.5 to 6 years mirrors the pattern seen at one month: this implies that the characteristics of intrauterine growth, leading to the typical infant morphology, are compensated by and large from 1.5 to 6 years (this can be also seen by averaging the increments in the two phases leading to a roughly constant pattern). On the other hand the relative increments from one month to 1.5 years show a constant pattern, except for bihumeral

Table 3. Means and standard deviations of % increments x̄ (s).

Variable		1 month x̄	1 month (s)	1 month to 1.5y x̄	1 month to 1.5y (s)	1.5y to 6y x̄	1.5y to 6y (s)	6y to T6girls x̄	6y to T6girls (s)
Bihum. W.	m	29.0	(2.0)	19.7	(2.1)	14.3	(2.0)	9.0	(1.4)
	f	32.4	(2.0)	21.4	(2.5)	16.0	(1.8)	10.0	(3.0)
Biiliac W.	m	31.8	(2.1)	18.2	(2.2)	17.2	(2.1)	8.8	(1.0)
	f	31.3	(1.9)	18.0	(2.2)	18.4	(2.1)	9.7	(2.7)
Sit. H.	m	36.0	(1.6)	16.7	(1.6)	16.4	(1.4)	9.8	(1.0)
	f	37.6	(1.5)	16.9	(1.7)	17.9	(1.8)	10.5	(2.4)
Stand. H.	m	29.8	(1.3)	16.3	(1.1)	19.9	(1.2)	12.1	(0.8)
	f	31.7	(1.2)	16.9	(1.2)	21.8	(1.3)	12.8	(2.8)
Leg H.	m	23.0	(1.5)	15.8	(1.6)	23.8	(1.6)	13.1	(1.2)
	f	24.9	(1.5)	16.8	(1.8)	26.2	(1.9)	13.9	(5.0)
Arm L.	m	27.0	(1.7)	15.8	(1.8)	20.8	(1.6)	11.8	(1.0)
	f	28.8	(1.8)	16.4	(1.7)	22.9	(1.8)	12.8	(3.5)

Variable		T6girls to T6 x̄	T6girls to T6 (s)	PS level x̄	PS level (s)	PS spurt x̄	PS spurt (s)
Bihum. W.	m	2.0	(3.4)	9.4	(2.6)	16.4	(4.5)
	f	0.0	(0.0)	8.0	(2.8)	12.3	(3.6)
Biiliac W.	m	3.4	(3.3)	9.3	(2.2)	11.3	(2.6)
	f	0.0	(0.0)	10.5	(2.7)	12.3	(3.2)
Sit. H.	m	2.6	(2.3)	6.9	(2.0)	11.6	(2.2)
	f	0.0	(0.0)	7.9	(2.2)	9.2	(2.2)
Stand. H.	m	3.5	(2.8)	9.4	(1.9)	9.0	(1.5)
	f	0.0	(0.0)	9.9	(2.0)	6.9	(1.4)
Leg H.	m	5.5	(4.2)	11.3	(2.9)	7.6	(2.0)
	f	0.0	(0.0)	11.5	(3.0)	6.6	(2.4)
Arm L.	m	3.1	(3.5)	10.2	(2.1)	11.2	(2.7)
	f	0.0	(0.0)	10.4	(2.5)	8.8	(2.1)

width. The delay of the male PS leads to a relatively large increment for legs and a small one for bihumeral width and sitting height.

The relative increments due to the spurt result in final morphological changes: bihumeral width increases substantially, legs only a little. The interaction term measures how the sex differences vary from variable to variable (seen in non-parallelism of pairs of lines in figure 2). The main source of interaction lies in the behaviour of biiliac width, but in certain phases sex-specific growth differences in legs and bihumeral width contribute also to interaction (see for example the lines corresponding to the PS). Except for the sex effect for the increment due to level and the interaction from 6 years to T6girls, all main effects and interactions are statistically highly significant. The respective p-values are mostly smaller than 10^{-15}.

Table 4 shows the average sex differences (boys-girls) in the increments during the various growth phases, and provides a breakdown for the source of the adult sex differences seen in table 1. Table 5 provides similar information in terms of percentages: the percentage contribution to the adult sex difference in each phase is given

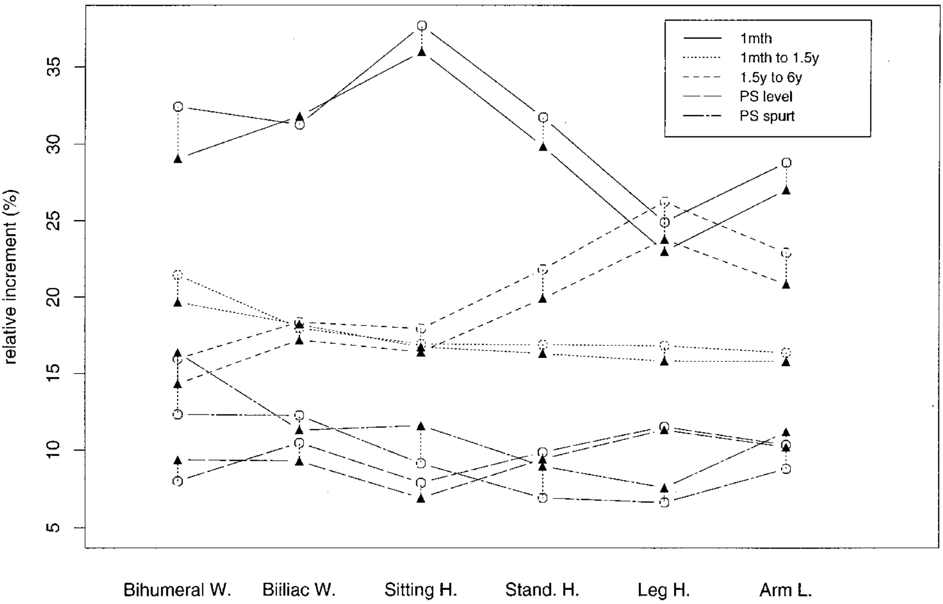

Figure 2. Average percentage contribution of various increments (across variables) for boys (▲) and girls (○).

Table 4. Average sex difference in various phases of growth (in cm).

	1 month x̄	1 mth to 1.5y x̄	1.5y to 6y x̄	6y to T6girls x̄
Bihum W.	0.0	0.2	0.0	0.0
Biiliac W.	0.2	0.1	−0.3	−0.2
Sit. H.	0.6	0.8	−0.4	−0.1
Stand. H.	0.8	1.2	−0.6	0.3
Leg H.	0.2	0.4	−0.1	0.3
Arm L.	0.6	0.7	0.0	0.1

	T6girls to T6 x̄	PS level x̄	PS spurt x̄
Bihum W.	0.9	1.0	2.2
Biiliac W.	1.0	−0.3	−0.3
Sit. H.	2.5	−0.5	2.8
Stand. H.	6.3	0.5	4.5
Leg H.	4.6	0.7	1.3
Arm L.	2.5	0.6	2.5

(except for biiliac width). Figure 3 shows the average percentage sex differences graphically for bihumeral width, sitting and leg height and arm length.

Size at one month and the increment from 1 month to 1.5 years is consistently somewhat larger for boys, in particular for sitting height. Part of the latter difference is lost from 1.5 years until the onset of the PS for girls. Otherwise, differences during this period are small. The later PS for boys accounts for about 64% of the adult sex difference for legs but only for about 19% for bihumeral width. For sitting height and arm length the later PS for boys, and the more intense PS, contribute about

Table 5. Percentage contribution to adult sex difference in various phases of growth

	1 month $\bar{x}$	1 mth to 1.5y $\bar{x}$	1.5y to 6y $\bar{x}$	6y to T6girls $\bar{x}$
Bihum W.	0.0	4.4	0.2	1.3
Sit. H.	10.4	13.9	−6.9	−1.0
Stand. H.	6.0	8.9	−4.2	2.2
Leg. H.	2.6	5.3	−2.1	4.5
Arm L.	8.6	9.7	−0.4	1.4

	T6girls to T6 $\bar{x}$	PS level $\bar{x}$	PS spurt $\bar{x}$
Bihum W.	19.0	21.0	49.7
Sit. H.	45.8	−7.8	48.7
Stand. H.	48.4	3.9	34.7
Leg H.	63.6	9.0	17.3
Arm L.	35.7	8.7	36.1

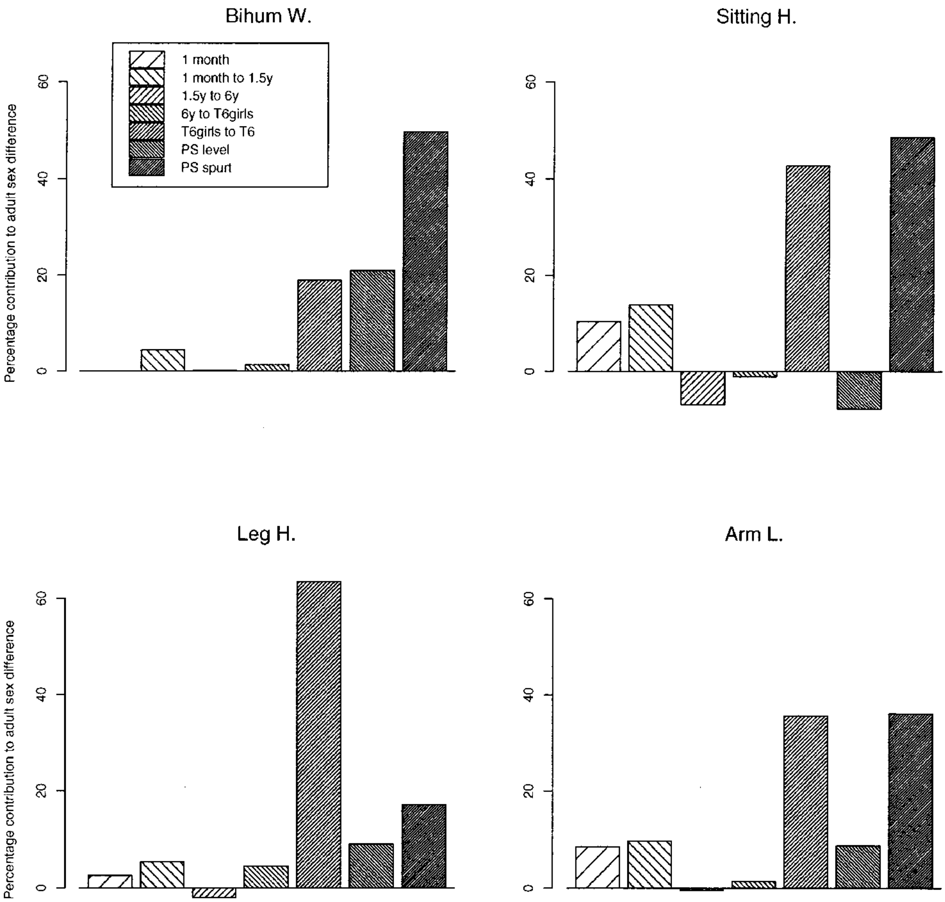

Figure 3. Average percentage contribution to adult sex difference in various growth phases for bihumeral width, sitting and leg height and arm length.

equally to the adult sex difference. Not surprisingly, standing height behaves in a manner intermediate between legs and trunk: the later PS contributes 48%, the more intense PS 35% to the adult sex difference.

Biiliac width, characterized by an almost equal adult size for both sexes, shows small ups and downs in the absolute sex difference: boys have a greater increase till 1.5 years, a smaller one from 1.5 years to the onset of the PS for girls, and a greater one due to the later PS and a smaller one due to a larger adolescent gain for girls.

4. Discussion

Boys gain their excess (as compared to girls) adult size in markedly different ways for the different somatic variables (biiliac width—with a similar adult size—is a special case and will be discussed below). While prepubertal sex differences are small (consistent with Tanner *et al.* 1976, Largo *et al.* 1978, Hauspie *et al.* 1985, Koziel *et al.* 1995), we find nevertheless an interesting pattern of changes: boys reach higher averages for trunk length, arm length and, to a lesser extent, also for supine length already at one month. They also have greater increments from one month until 1.5 years in the same variables. This is tentatively attributed to a rise in the testosterone level in infancy for boys (review in Forest 1989). Early childhood (from 1.5 years to 6 years) seems to favour girls: in this phase they usually have larger increments than boys. Interestingly, males with their characteristically broad adult shoulders, show little difference from girls in bihumeral width until the age of average onset of the PS for girls.

At the average age of onset of the PS for girls we find, therefore, just slightly higher average absolute sizes for boys. For all variables studied, boys experience a later onset of the PS by about 1.5 years (Sheehy *et al.* 1999), allowing boys to gain substantially in size relative to girls so that boys begin puberty with a greater size than that of girls. The delay explains 63.6% of the adult difference for legs, but only 19% for bihumeral width. This can be associated with previous findings (Gasser *et al.* 1991a, b, Sheehy *et al.* 1999): independent of sex, bihumeral width gains a lot in size due to an accentuated pubertal velocity peak, while legs have a high prepubertal velocity level and a meager spurt. This fact explains why the adult sex difference for legs comes mostly from the later onset of the PS for boys. The adolescent period contributes a hefty 71% of the adult sex difference for bihumeral width, 39% for height, 45% for arm length, 41% for sitting height and only 26% for leg height. It should be noted that bihumeral width experiences changes during puberty not only in the skeletal dimension: boys gain principally in muscle volume and girls in fat volume—biacromial width (used by Tanner *et al.* 1976 and Hauspie *et al.* 1985) would in this respect be a more appropriate measure of shoulder width. When subdividing the adolescent increment into a contribution associated with the basic velocity level and one associated with the pubertal spurt, it becomes evident that the increment due to the spurt contributes overwhelmingly to sex dimorphism. For the most frequently studied variable 'height', 48% of the adult sex difference can be attributed to the later onset of puberty for boys, 35% to the more intense PS and 13% to prepubertal growth. When subdividing the adolescent period into an early, middle and late phase (T6 to T7, T7 to T8, T8 to T9) it becomes evident that boys gain most during the early phase and least during the late phase. This is in line with the results of Sheehy *et al.* (1999).

For height the results of Largo *et al.* (1978) agree well with ours. In comparison with Tanner *et al.* (1976), Hauspie *et al.* (1985) and Koziel *et al.* (1995) the main difference is that the contribution due to the delayed PS is greater in relative terms (and consequently the adolescent contribution is smaller). This is probably largely attributable to methodological differences and only to a lesser extent to differences in samples. In Gasser *et al.* (1984b) it was shown that the Preece-Baines model—used by Hauspie *et al.* (1985) and Koziel *et al.* (1995)—tends to underestimate the onset of the PS more for girls than for boys, leading to a corresponding overestimate for the delay. For sitting height the results of Tanner *et al.* (1976) and Koziel *et al.* (1995) agree reasonably well with ours, whereas Hauspie *et al.* (1985) shows again a much greater contribution due to the delay.

For the shoulder, the relative contribution of adolescent growth is very large in our results, but not in those of Tanner *et al.* (1976) and Hauspie *et al.* (1985). This might be due to the difference between biacromial and bihumeral width, but could again be attributable to methodological differences. The graphical displays provided by structural average velocity curves (Gasser *et al.* 1991b) also demonstrate the critical importance of adolescence for bihumeral growth.

Biiliac width is exceptional in that the adult sex difference is negligible, despite the fact that boys experience their PS later than girls for this variable, too. As it turns out, there is no single factor which allows girls to achieve almost the same adult size despite a shorter growth period. Boys are slightly bigger at one month and their increments until 1.5 years are also slightly larger on the average, than those for girls. Girls then increase more in size than boys from 1.5 years till the onset of their PS. Boys gain about 1 cm more in prepubertal growth than girls due to their later onset of the PS. However, during adolescence girls show a larger increase in biiliac width, leading eventually to a small adult sex difference of 0.2 cm in favour of boys. Overall sex differences remain small over the whole growth period. This pattern agrees reasonably well with Tanner *et al.* (1976) and Hauspie *et al.* (1985).

Variables differ substantially at 1 month in the percentage of size reached, leading to a morphology which is radically different from the adult one. As seen in figure 2, the phase from 1.5 to 6 years largely compensates for this pattern; bihumeral and biiliac width are, however, still relatively small. The phase from 1 month to 1.5 years shows an intermediate pattern and represents, as said earlier a transition from intrauterine to extrauterine growth. The increment due to the PS brings a further—and last—change in morphology: the two widths show a substantial increase relative to the other variables, and the trunk relative to the legs.

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Zusammenfassung. Während Übereinstimmung darüber herrscht, das Geschlechtsunterschiede in der Körperhöhe bis zum Beginn des puberalen Wachstumsspurts bei Mädchen gering sind, gab es einige Diskussionen hinsichtlich der Frage, welche der verschiedenen Wachstumsphasen in welchem Ausmaß zu dem im Erwachsenenalter beobachtbaren Geschlechtsunterschied in der Körperhöhe von ca. 13 cm beitragen. Zwischen den Autoren gibt es keinen Konsens darüber, in welchem Umfang dieser Unterschied durch das späte Auftreten des puberalen Wachstumsspurts (PS) bei Jungen bedingt ist und welchen Beitrag der intensivere PS liefert. In der vorliegenden Arbeit wird dieses Problem für die Variablen Körperhöhe, Sitzhöhe, Beinlänge, Armlänge, Epikondylenbreite des Humerus und Beckenbreite untersucht. Die Beckenbreite stellt eine Ausnahme dar, da beide Geschlechter etwa gleiche Maße im Erwachsenenalter aufweisen, Mädchen jedoch eine kürzere Wachstumsperiode haben. Bei einem Vergleich mit Mädchen weisen die Zuwächse bei Jungen für die verschiedenen Variablen sehr unterschiedliche Muster auf: bei den Beinen ist das durch den späteren Wachstumsspurt bedingte zusätzliche Wachstum für einen Großteil (64%) des Geschlechtsunterschieds im Erwachsenenalter verantwortlich. Für die Epikondylenbreite des Humerus und die Sitzhöhe trägt andererseits der intensivere Wachstumsspurt fast 50% zum Geschlechtsunterschied im Erwachsenenalter bei. Eine variablenübergreifende Analyse zeigt, dass Zuwächse im Alter zwischen 1.5 und 6 Jahren Abweichungen der Morphologie des Säuglings von der Morphologie im Erwachsenenalter im wesentlichen ausgleichen.

Résumé. Alors q'on s'accorde pour penser que les différences sexuelles en stature sont petites jusqu'au début de la poussée de croissance pubertaire des filles, il y a par contre débat quant à la question de savoir combien et dans quelle mesure, diverses phases de croissance contribuent à produire la différence staturale moyenne d'environ 13cm entre les sexes chez les adultes. Il n'y a pas d'accord clair entre les auteurs à propos de l'origine de cette différence: retard de la poussée pubertaire des garçons ou poussée pubertaire plus forte. Dans cet article nous reprenons cette question en nous intéressant à la stature, à la taille assis à la longueur de la jambe, à la longueur du bras, à la largeur bihumérale et au diamètre biiliaque. Le diamètre biiliaque est un cas spécial parce que les deux sexes ont approximativement la même valeur adulte, mais les filles ont une période de croissance plus courte. Les gains des garçons lorsqu'ils sont comparés à ceux des filles, présentent des formes très différentes suivant les variables: pour les jambes, la croissance additionnelle due à une poussée plus tardive est responsable de la plupart des différences adultes entre les deux sexes (64%). Par ailleurs la poussée pubertaire plus forte est responsable d'environ 50% des différences sexuelles adultes. Une analyse prenant en compte toutes les variables montre que les accroissements de 1.5 à 6 ans compensent largement les déviations en morphologie infantile par rapport à la morphologie adulte.