

A STUDY OF RELATION BETWEEN PHYSICAL GROWTH AND SEXUAL MATURITY IN GIRLS—V

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ABSTRACT

The findings indicate that sexual maturity would be initiated only after the attainment of requisite morphological body size such as weight on an average nearly 27 kg and height of 137 cm, irrespective of age and SES. The girls from LSES were chronologically older throughout the span of pubertal growth. However, they took lesser time to reach full maturity after the attainment of mid-pubertal growth compared to USES.

Menarche appeared after attaining about a minimum weight of 35 kg, height of 143 cm and bicristal breadth is 24 cm. Its appearance followed the attainment of peak height velocity and 3rd developmental stage of breast and/or pubic hair. It, however preceded the attainment of weight and bicristal breadth peak velocities.

Key words: Relationship, Growth, Maturity.

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*Received for publication May 22, 1987;
Accepted July 17, 1990*

Physical growth is known to have a close relationship to sexual development and skeletal maturity. The dynamics of physical growth and sexual maturity of children is fairly complicated biological process(1-4) and vary from individual to individual(4-8). It is also reported to be different in different racial groups(9-11) and is likely to be influenced by environmental factors(12). Boas as early as in 1932(13) had focussed the attention to the relation between various aspects of growth and menarche which represents a definite point of sexual maturity in girls. The present study relates the physical growth and sexual maturity in North Indian school girls.

Material and Methods

Physical* growth and development of secondary sex characters and menarche in girls were assessed in the same 791 girls.

In order to obtain the relationship between physical and sexual growth, the development of sexual characteristics were expressed in numerical sequence of scores for breast-pubic hair-axillary hair stages in that order. The number of permutation and combinations between various developmental stages of sex characters resulted in more than 30 combinations. Eight combinations were picked upto represent the onset, midpoint and complete growth of breast, pubic hair and axillary hair. Thus the girls who had attained these combinations at any point of observation were placed in 8 degree in such a way to cover the onset, mid and complete sex development. The details of observations under each combination and permutation of various sexual characteristics are shown in Table I.

Means of various somatic measurements were calculated for each group

TABLE I—*Number of Observations Made in Each Secondary Sex*

| Developmental groups | USES | LSES |
|----------------------|------|------|
| 221 | 96 | 98 |
| 221 | 60 | 37 |
| 222 | 44 | 33 |
| 332 | 39 | 37 |
| 432 | 39 | 25 |
| 542 | 42 | 28 |
| 552 | 39 | 29 |
| 553 | 54 | 29 |
| Total | 413 | 316 |

211 : Breast development (1st stage);

353 : Full development of breast, pubic hair and axillary hair in that order.

1 : No development of breast, pubic and axillary hair.

separately for upper and low socio-economic status girls and illustrated graphically.

The relationship between menarche and physical growth was worked out with only three measurements, viz., weight, height and bicristal breadth. To attain early, middle and late menarche, means were computed and level of significance were adjudged by 't' test between two means. The degree of association between developmental stages of sex characters with menarche and between peak velocities of weight, height and bicristal breadth with menarche was determined and shown graphically.

Results

Relationship between various stages of sexual growth and body measurements are presented in *Figs. 1-4*. Stages '211' meant that breast was at Stage-II and pubic and

axillary hair had not appeared. Stages '553' represented that complete development of the breast, pubic hair and axillary hair. These were correlated to each of the body measurements. In *Figs. 1-4*, composite stages of sexual development and mean ages are indicated below the diagram.

In the sexual stages from '211' to '221' there was no appreciable gain in various body dimensions either in LSES or in USES girls. However, a few measurements i.e., weight, height, height acromian, arm length, leg length, bicristal breadth and hip circumference showed some increase in USES girls only (*Figs. 2 & 3*). Similarly, when the girls attained composite development stage from '221' to '222' i.e., appearance of axillary hair, no significant growth achievement was noticed in any dimension irrespective of SES. Nevertheless, a significant gain in various linear and circumferential measurements was observed from stages '222' to '322' in both SES girls. It also shows that LSES girls took one year to attain mid-puberty while USES girls only half year (*Figs. 1-3*).

Stage '332' represents the mid-puberty and age of its attainment corresponding to ages at peak velocities of most of linear and circumferential dimensions. Further, rapid growth was observed when the girls reached from a stage '432' to '542', i.e., when breast is fully matured. However, linear and circumferential measurements did not grow significantly when pubic or axillary hair matured to attain adult size, i.e., from stages '542' to '553' (*Figs. 1-3*).

It was found that LSES girls attained adult size, i.e., from stages '542' to '553' (*Figs. 1-3*). It was found that LSES girls attained complete pubertal growth from mid-growth (332-553) in lesser time (1.3 year) compared to USES girls (1.7 years) while the situation was converse while

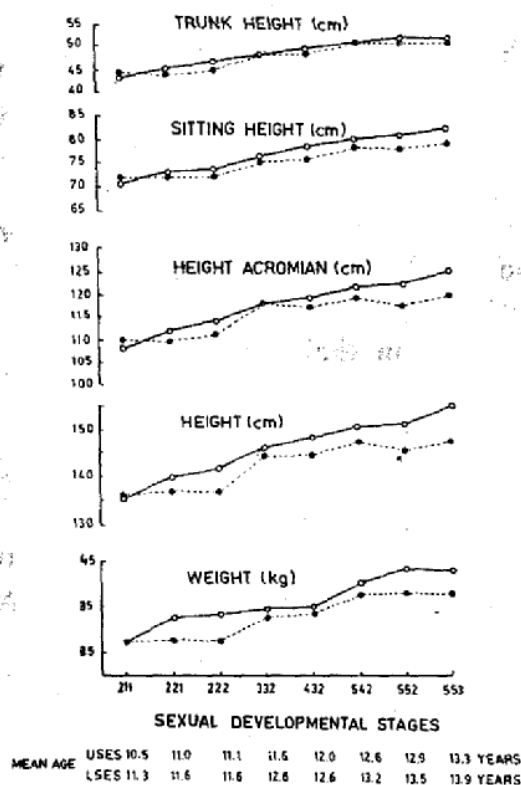


Fig. 1. Relationship of different developmental stages of secondary sex characters with weight, height, height-acromian, sitting and trunk height in girls.

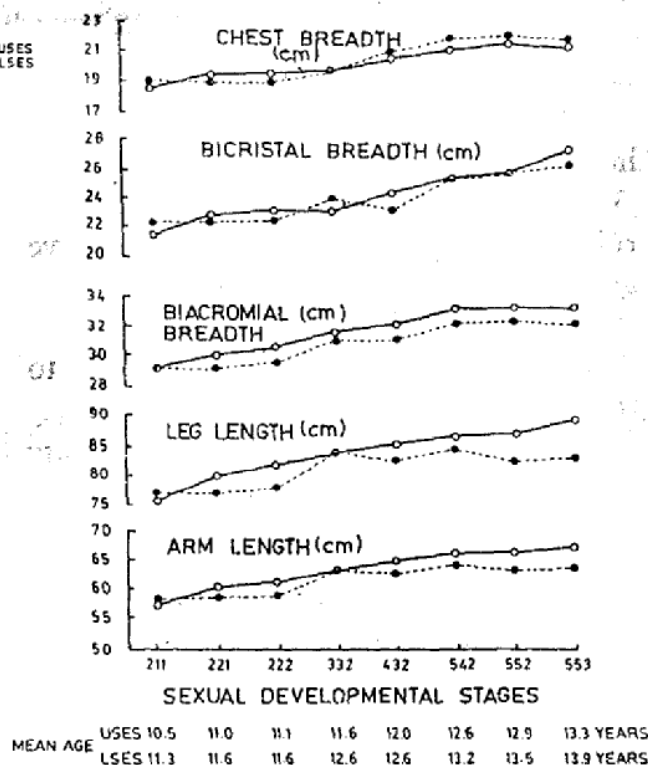


Fig. 2. Relationship of different developmental stages of secondary sex characters with body lengths and breadths in girls.

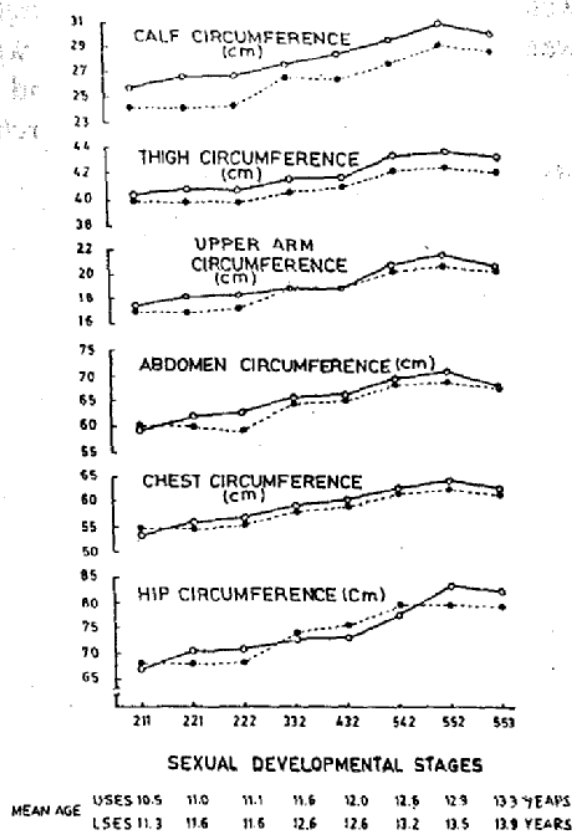


Fig. 3. Relationship of different developmental stages of secondary sex characters with various circumferences in girls.

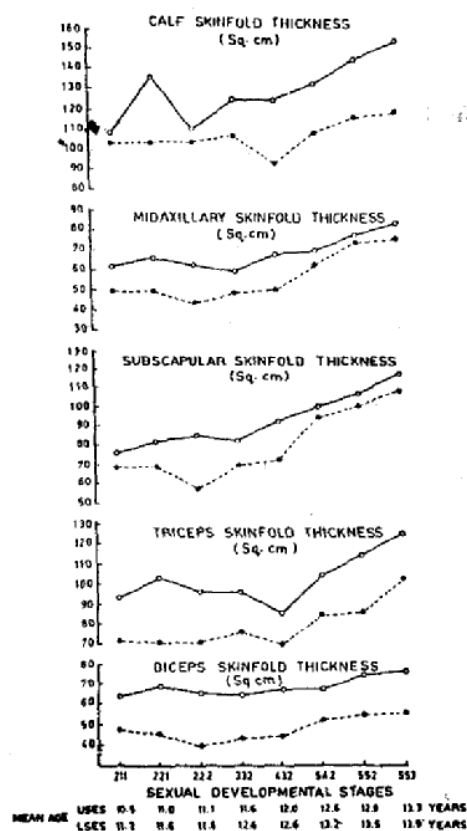


Fig. 4. Relationship of different developmental stages of secondary sex characters with various skin-folds in girls.

attaining mid-pubertal growth from the onset.

Figure 4 reveals no significant change in various skinfolds from stages '221' to '332' on both SES girls and these skinfolds remained static or obtained negative growth. Thereafter, all the skinfolds after stage '332' increased markedly till the last stage of development '553' unparalleled to the growth of sexual development stages.

It was observed that onset of secondary sex characters occurred only when physical growth reached certain level of physical maturity as evident from each linear and circumferential measurements irrespective of age and SES. The onset of sexual growth occurred only when both SES girls had attained almost the same weight (27 kg) and height (137 cm). Although, the growth of other dimensions were also closed in both SES, yet the LSES girls were significantly older ($p < 0.01$) than those of USES girls and LSES girls remained, thereafter, smaller in overall size and chronologically older at each combination of sexual development stages. It was also apparent that development of breast matured parallel to the growth phases of linear and circumferential irrespective of age and social strata of the girls. While it was not found true in case of pubic or axillary hair development.

Relationship of menarche was ascertained with three selected physical measurements, viz., height, weight and bicristal breadth.

It was taken with the view that height indicates the sum of all the skeletal growth and so does the weight, including fat and muscles whereas, bicristal breadth was taken considering its widening as the indication of the onset of pubertal growth in females. Weight and bicristal breadth was also found to have highest discriminating values *vis-a-vis*, menarcheal status.

In order to assess the relation of these measurements with menarche, girls were divided into 3 groups of early, normal, and late maturity, girls falling between ± 1 SD around mean age at menarche were grouped as normal (M2) and those lower than this, as early (M1) and those higher, late (M3) in their menarche attainment. USES and LSES girls were considered separately (Table II). Insignificant difference was observed in the mean values of weight, height and bicristal breadth in the girls of two SES indicating that menarche in girls would occur only after achieving certain level of physical maturity viz., body weight, 35 kg, height, 143 cm and bicristal breadth 24 cm irrespective of age and SES. Significant difference was observed in mean heights of M1 & M3. This is perhaps due to statistically small and unequal sample size.

Figure 5 shows menarche correlated well with the peak velocities of height, weight and bicristal breadth and also with the developmental stages of breast and of pubic hair. It shows that age at menarche, i.e., 12 year in USES and 12.8 in LSES girls had appeared in girls only after they had achieved peak height velocity which occurred between 11-12 years of age (mid-point 11.5) and prior to attainment of peak weight and bicristal breadth velocities which were between ages 12-13 in USES and 13-14 years in LSES girls (mid points 12.5 and 13.5, years respectively). Menarche followed the attainment of 3rd stages of breast and fourth stage of pubic hair.

Discussion

Pubertal growth is a co-ordination between the physical attributes, secondary sex characteristics and development of internal

TABLE II—Mean Height, Weight, Bicristal Breadth at On set of Menarche

| Socio-economic status | Mean age | Menarche | Weight | P< | Height | P< | Bicristal breadth | P< |
|-----------------------|----------|----------------|--------|------------------|--------|--------------------|-------------------|------------------|
| Upper | 10.56 | M ₁ | 35.2 | ns ₁₂ | 142.9 | ns ₁₂ | 24.0 | ns ₁₂ |
| | 12.22 | M ₂ | 38.2 | ns ₂₃ | 151.1 | ns ₂₃ | 25.2 | ns ₂₃ |
| | 13.62 | M ₃ | 40.0 | ns ₁₃ | 154.3 | 0.05 ₁₃ | 25.6 | ns ₁₃ |
| Low | 11.54 | M ₁ | 33.7 | ns ₁₂ | 144.4 | ns ₁₂ | 24.6 | ns ₁₂ |
| | 12.87 | M ₂ | 35.7 | ns ₂₃ | 145.4 | ns ₂₃ | 24.9 | ns ₂₃ |
| | 14.62 | M ₃ | 36.9 | ns ₁₃ | 148.1 | ns ₁₃ | 25.2 | ns ₁₃ |

Menarche appeared below -1 SD around mean = Early (M₁)

Menarche appeared between ± 1 SD around mean = Normal (M₂)

Menarche appeared above +1 SD around mean = Late (M₃)

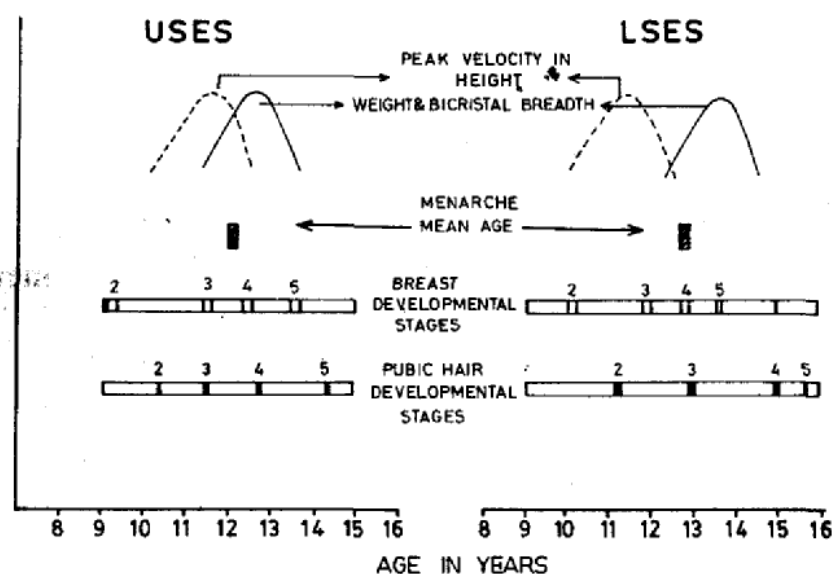


Fig. 5. Relationship of menarche with peak velocities in height, weight and bicristal breadth and with developmental stages of secondary sex characters.

sex organs. A close association between physical and sexual growth has been recognised for long though largely the emphasis has been placed on correlation of menarche with weight or height(4,15-23). These investigators had also observed a good relationship between the appearance of secondary sex characters and peak height velocity.

Based on these, composite staging of total development could be divided into two major phases – phase one extending from the onset of the development of the three secondary sex characters (represented by '211') to the mid-puberty point (represented by '332') and phase two from the mid-puberty point to the full development (represented by '553').

The following correlations emerged: (i) there was a strong correlation of body weight with the onset of breast development. The breast development had begun only after the body weight had reached 27 kg of weight, and 137 cm of height. This happened irrespective of chronological age of the subject or the socio-economic status. This has not been mentioned in the literature by others; (ii) A significant correlation was observed between most of the physical measurements and the various developmental stages of the breast while no consistent association was found with pubic or axillary hair growth; (iii) The peak velocity of growth of height and its components as well as of breadth and the circumferential measurements coincided with the mid-puberty point, i.e., at stages '332' which corresponded with the third stage of breast and of pubic hair and second stage of axillary hair; and (iv) Skinfold thicknesses showed apparently no association with the development of secondary sex characters. Fat consistently decreased in the body upto the mid-pubertal stages '332'. Thereafter, there was a rapid increase independent of the development of secondary sex characters.

The LSES girls had not only a delayed onset but also the first phase, i.e., from onset to mid-puberty point was also slower than USES girls. Later on, there appeared to be, a catch-up phenomenon to that much that the second phase of the development was achieved in a shorter period of time. It is perhaps that sexual growth matched the tempo of physical growth. As mentioned in earlier communications, LSES girls showed delayed physical growth by one year and peak velocity as in most of the somatic measurement.

Faust(24) reported significant association with sitting height, bicristal and biacromial breadths with various stages of de-

velopment of secondary sex characters but no correlation was seen with subcutaneous fat except that fatter girls attained maturity earlier than lean girls. This was true in the present study too. Garn and Haskell(25) observed a linear relationship between fat size and developmental status. These observations were based on radiological study. Reynolds(26) believed that there was an established relationship between various developmental stages and with height or weight irrespective of the criteria used to classify the maturity groups. These workers(25,26) and Bodzsar(27) reported that early maturers were obese and faster in the growth and maturation compared to late maturers. Agrawal *et al.*(4) found significant correlation of secondary sex characters with height, weight and circumferences of chest and arm but not with head and leg circumferences.

A remarkable correlation between the accelerated weight and bicristal breadth velocity and onset of menarche was observed in present girls. As far as height was concerned, menarche coincided with its peak velocity. Its onset also coincided with the attainment of third stage of breast and pubic hair. It can be said that menarche would occur when a girl has almost crossed half way of her puberty. Marshall(12) reviewed the world literature on growth and has commented on the consistent relationship of menarche to peak height velocity and ultimate adult stature. He suggested if this fact was true then the mean age at menarche in different populations might be taken as an indicator to assess the relative rate of progress towards adult stature during adolescent growth irrespective of the chronological age.

The present study also showed that menarche occurred only when body attained certain requisite morphological maturity

and size as girls with early, normal and late menarche had no significant difference in height, weight and bicristal breadth at the time of onset though chronologically there was a difference of approximately three years. The findings of minimum weight of 46-47 kg required to attain menarche was reported by Frisch and Revelle(28) and revised opinion about the need of overall body build in 1974(29) appeared correct and consistent with the present findings. It is evident that chronological age played the least role and sexual growth occurred only when body achieved a requisite physical maturity.

Acknowledgements

This study was financed by the Indian Council of Medical Research, New Delhi.

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NOTES AND NEWS

SHANTI SWARUP BHATNAGAR AWARD

Dr. M.K. Bhan, Additional Professor in Pediatrics at the All India Institute of Medical Sciences, New Delhi is the recipient of the Shanti Swarup Bhatnagar Award for the year 1990 for his work in the field of "Diarrheal Diseases in Children". Heartiest congratulations from the Pediatric fraternity.

Editor