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Maturity Gradients based on anthropometric measures of adolescent girls from Shimla, Himachal Pradesh

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Abstract
The present cross-sectional study has been conducted with a view to evaluate the maturity gradients among 201 adolescent girls ranging in age from 12 to 18 years, residing in district Shimla, Himachal Pradesh. Anthropometric measurements like height, weight, upper-arm circumference, waist circumference, hip circumference, calf circumference, humerus bicondylar diameter and femur bicondylar diameter were taken on each subject by using standard techniques. Maturity gradients of all anthropometric measurements were calculated and expressed in percentage of its adult value. Height of the girls attained maturity value earlier than weight. Humerus bicondylar breadth was ahead in its maturity than femur bicondylar breadth at all ages. At age 12, waist circumference (87.44%) is the most advanced in its maturity and upperarm circumference (79.72%) is the lagging one in its maturity. Out of all circumferences, upperarm circumference attained its adult value earlier than waist, hip and calf circumference. Girls of the present study showed later maturation in height and weight as compared to Garhwali and Jaunsari females but early maturation than Rajput Kullu girls.

Keywords: Maturity gradients, anthropometric measurements, adolescent girls

Introduction
Adolescence is a transitional stage of development where an individual transforms from childhood to adulthood. It is a crucial stage of growth with physical and hormonal changes that leads to sexual maturation and reproductive capacity [1, 2, 3, 4]. Growth refers to measurable changes in body size, physique, and body composition. The various stages of growth can be used as an analytical tool for the analysis of maturation as it occurs at specific time but is influenced and regulated by environment and genetic factors. Although the maturation of different body parts occur at different times but these are interrelated to each other [5]. Growth focuses on size, and maturation focuses on the progress of attaining size [6]. All body parts, tissues, organs and organ system mature at different rates and at different interval of time. There is a change in all bodily proportions of a child as the age advances [7]. Maturation processes are characterized by wide variations in size, body composition, rate of growth and timing of biological maturation. The process of growth is comparatively faster which begins with fertilization continues till the attainment of maturity. After maturation, growth slows down in linear measures and continues to be operative in transverse and circumferential measurements which finally decline in the older age [8]. All mammals including humans follow a cephalo-caudal gradient pattern of growth. Legs grow relatively faster than other post-cranial body segments between birth and puberty [9]. Skeletal maturity or bone age describes the degree of biological maturation [10]. On the basis of stages of skeletal maturity at a particular age, children can be classified as early or late maturers. Although there are individual variations in the stages of attainment of maturity but the sequence of these stages remains the same in all individuals [11].
The method suggested by Tanner has been widely adopted by clinicians to ascertain the sexual maturity of an individual. However, maturity calculated on the basis of anthropometric measurements and body composition is found to be more reliable than the scores based on former method. Literature revealed that very few studies have been conducted for the growth gradients on adolescent males and females [12, 13, 14, 15, 16, 17]. To augment data in this direction the present study has been designed to utilize the anthropometric measurements to monitor the maturity gradient among the adolescent girls of Shimla, Himachal Pradesh.

Material and Methods
A total sample of 201 adolescent girls residing in district Shimla ranging in age between 12 to 18 years were measured cross-sectionally for the eight anthropometric measurements. These included height, weight, four circumferences (waist, hip, upper-arm and calf) and two diameters (humerus bicondylar and femur bicondylar) were calculated by using standard techniques given by Weiner and Lourie [18]. Date of birth of each subject was also recorded after verifying the same from school registers. Recorded age was then converted into decimal age by using decimal age calender given by

Tanner *et al.* 1966 [19]. Prior permission was also taken from subjects, their parents and teachers before data collection. Subjects who are apparently healthy did not suffer from any illness or disease and having age ranging between 12and 18 years were included in this study. Growth gradient were computed for anthropometric measurements like height, weight, waist circumference, hip circumference, upper-arm circumference, humerus bicondylar diameter and femur bicondylar by taking age 18 as the level of maturity for these body measurements.

Results

Table 1 represents the descriptive statistics of maturity gradients for height, weight, circumferences (upper-arm, waist, hip and calf) and diameters (humerus bicondylar and femur bicondylar) among the adolescent girls residing in district Shimla. It is evident from the table 1 and fig. 1, 2 & 3 that at 12 years, of all the measures, Humerus bicondylar diameter showed most advanced maturity (93.13%) followed by femur bicondylar diameter (92.93%), height (87.56%), waist circumference (87.44%), calf circumference (83.80%), hip circumference (81.16%) and body weight (60.31%) was the most retarded measure. Humerus bicondylar diameter reaches maturity earliest at all ages as compared to femur bicondylar diameter (fig. 3). However, from 13 to 17 years, girls from Shimla were ahead in their maturity status in height at all ages as compared to weight. They attained 94.79 % of their height and 79.38 % of weight at 13 years and acquired 99.63 % of its mature value of height and 98.91% of weight at 17 years. Adolescent girls of Shimla mature earlier in height than weight. Of all the four circumferences (upper-arm, waist, hip and calf), waist circumference showed earlier maturation (87.44%) in its level at 12 years of age followed by calf circumference (83.80%), hip circumference (81.16%) and upper-arm circumference (79.71%). At 13 years of age, calf circumferences reached early maturation (93.03%) followed by waist (92.60%), hip (91.67%) and upper-arm (89.64%) circumference respectively. Waist circumference (99.14%) was the most advanced and hip circumference (94.42%) the most lagging in its level of maturity at 14 years of age. Upper arm circumference assumed advanced maturity at the ages of 15, 16 and 17 years respectively (fig.2).

Discussion

Maturity status of the child can be assessed either from dental maturity, skeletal development or from the development of secondary sex characteristics and is very important during the timing of pubescence as it provides a better judgement of the normality of growth [20, 21]. Many investigations have been done on the relationships between biological maturation and anthropometric characteristics of children by using maturity groups [22, 23, 24, 25, 26]. At the beginning of puberty it has been observed that early matures have higher dimensions than late maturers [27, 28, 29, 30]. In all mammals and human beings both cephalo-caudal and distal- proximal gradients exist.

Table 1 and fig. 3 clearly demonstrated that Humerus bicondylar breadth of girls of the present study matured earlier than their femur bicondylar breadth. In boys of Yamunanagar [17] and Spitian boys [31] femur bicondylar breadth matured earlier than humerus bicondylar breadth till 15 years, after which humerus bicondylar breadth took the lead. Although females are consistently more mature than males, the gradient of variation between dimensions is sex independent [32]. Out of all circumferences, upper-arm circumference attained its adult value earlier than other three circumferences i.e. waist, hip and calf circumferences. Height of the girls reached maturity earlier than their weight. Khariyal *et al.* (2012) [8] in their study on Garhwali and Jaunsari Rajput females demonstrated both cephalo- caudal and caudo-cephalic directions of maturations in upper arm length, forearm length, head length and stature. The adolescent girls from Shimla attained 94.79% of their adult value for height at 13 years which may be attributed to their peak height velocity between 12 and 13 years. They keep on adding in their weight all through adolescence due to deposition of fat and muscles and attain their adult value in this measure later than height. A comparison of maturity gradients of height and weight of adolescent girls of the present study has been made with the available similar data of Garhwali, Jaunsari and Kullu Rajput girls (Table 2 & 3, fig 4 & 5). It is clear that Garhwali girls matured earlier in weight and height than the adolescent girls of the present study. Girls of the present study showed similar results with Jaunsari girls in initial ages but after 14 years of age, adolescent girls of present study attained early maturation in both height and weight than Jaunsari girls. Maturity gradient for weight and height of adolescent girls of Shimla were also compared with Kullu Rajput girls, adolescent girls of the present study showed early maturation level for weight and height than Kullu girls [14]. It is evident from the comparison that girls of the same chronological age show a wide range of variability in somatic and biological maturation due to differences in developmental age.

Table 1: Maturity gradients of various anthropometric variables among adolescent girls of Shimla.

Age (years)	Height	Weight	Upper-arm Circumference	Waist Circumference	Hip Circumference	Calf Circumference	Humerus Bicondylar Breadth	Femur Bicondylar Breadth
12	87.56	60.31	79.72	87.44	81.16	83.80	93.13	92.93
13	94.79	79.38	89.64	92.60	91.67	93.03	95.66	94.52
14	95.90	85.88	95.39	99.14	94.42	97.95	96.56	95.53
15	98.17	94.14	99.81	99.48	98.46	97.47	98.01	97.26
16	98.68	98.47	99.91	98.61	99.41	99.51	99.10	97.55
17	99.63	98.91	99.76	99.58	98.64	98.13	99.64	98.27
18	100	100	100	100	100	100	100	100

Table 2: Comparison of maturity gradient for weight among adolescent girls of Shimla

Age	Present study	Garhwali	Jaunsari	Kullu
12	60.31	80.51	79.17	65.80
13	79.38	85.15	88.56	73.79
14	85.88	91.63	90.42	80.67
15	94.14	95.99	88.32	90.49
16	98.47	95.66	94.28	93.99
17	98.91	99.56	97.78	100
18	100	100	100	

Table 3: Comparison of maturity gradient for height among adolescent girls of Shimla

Age	Present study	Garhwali	Jaunsari	Kullu
12	87.56	93.81	91.99	88.86
13	94.79	95.91	94.40	92.57
14	95.90	98.20	96.80	94.93
15	98.17	98.29	97.76	97.38
16	98.68	99.26	97.92	97.95
17	99.63	100.02	99.35	100
18	100	100	100	

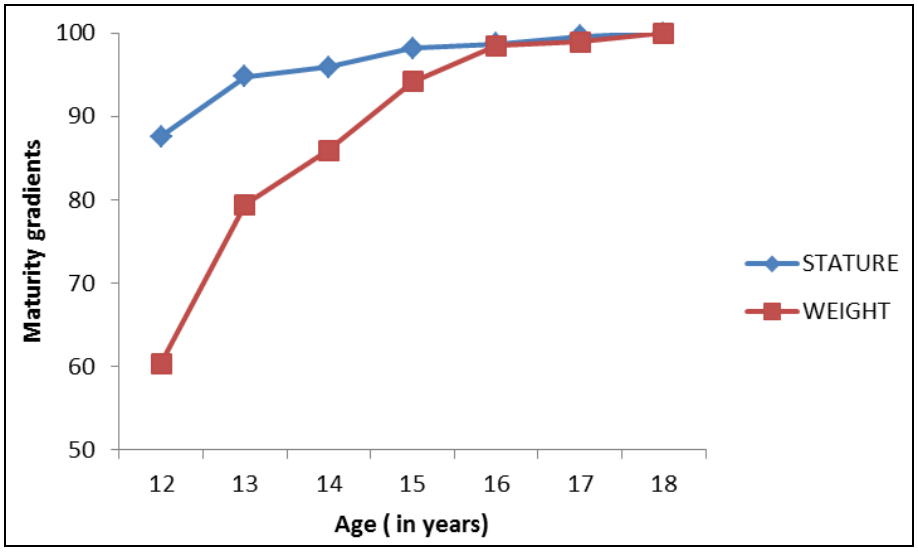

Fig 1: Maturity gradient of Stature and Weight among adolescent girls of Shimla

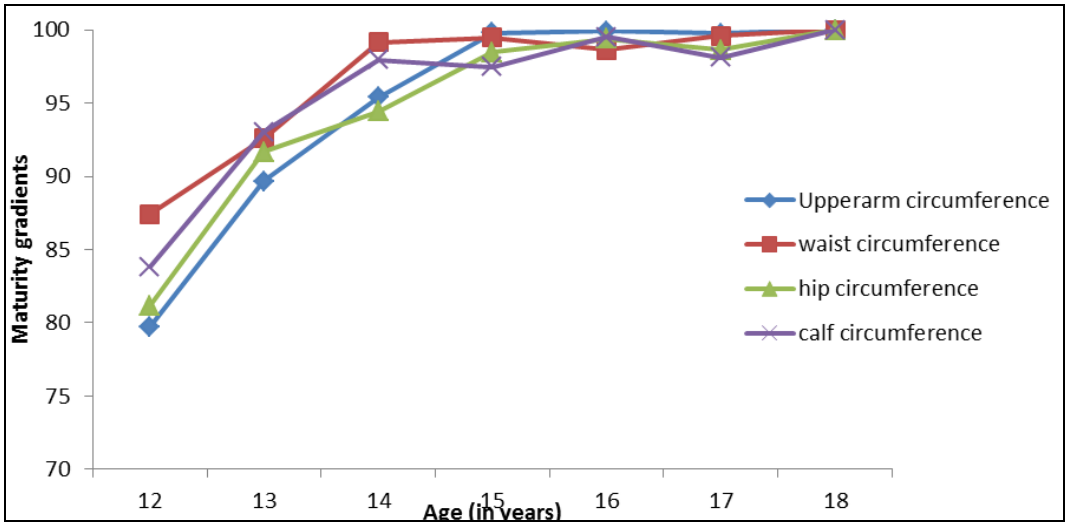

Fig 2: Maturity gradients of four circumferences among adolescent girls of Shimla

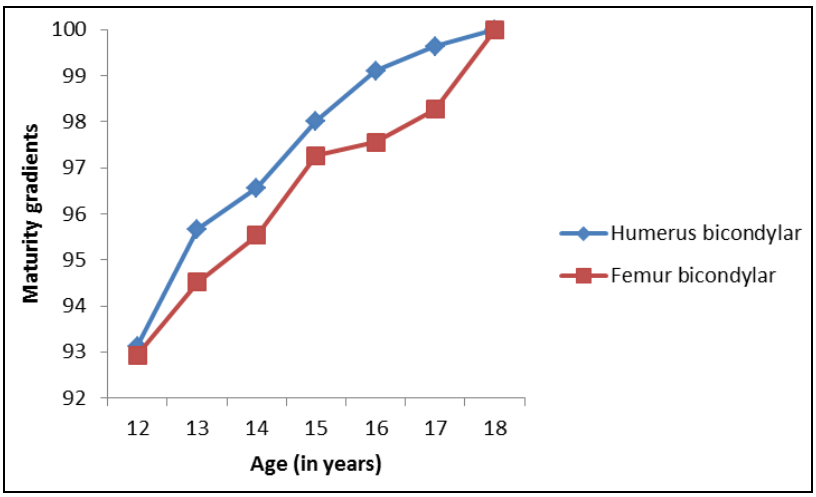

Fig 3: Maturity gradients of humerus bicondylar and femur bicondylar among adolescent girls.

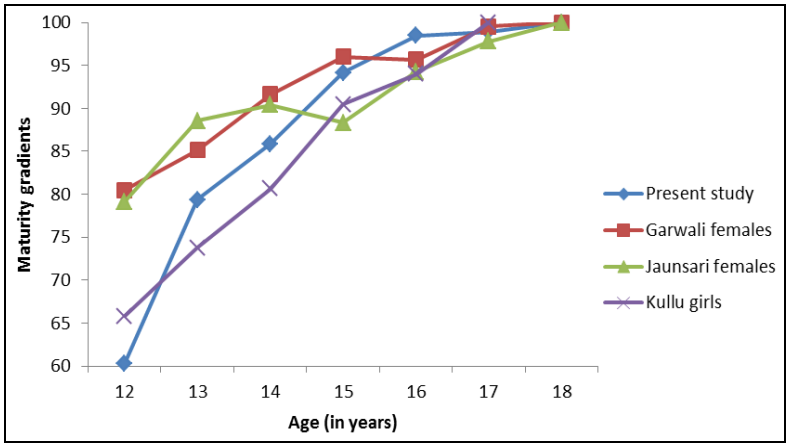

Fig 4: Comparison of maturity gradients of weight between different populations.

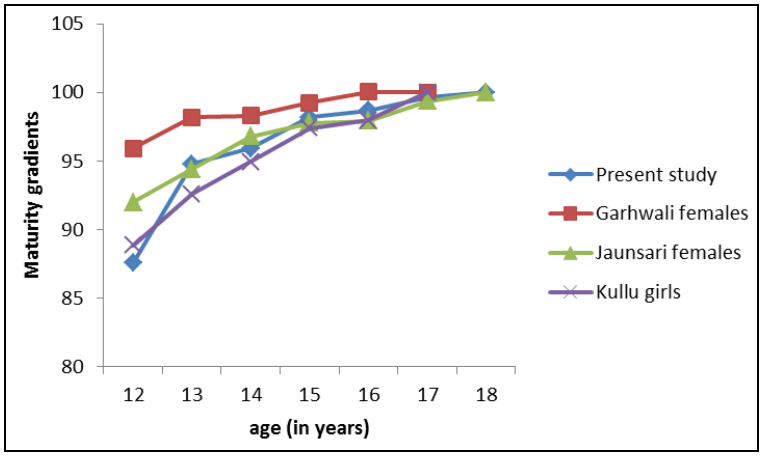

Fig 5: Comparison of maturity gradients of height between different populations.

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