A. SHARMA

A CROSS-SECTIONAL GROWTH STUDY OF SOME MODIFIED FRESH PELVIC MEASUREMENTS AND THE CORRELATION MATRICES

Measurements on human pelvis from foetal age to adulthood and of different population groups have attracted the attention of a large number of scholars since the 19th century (e.g. Thompson 1899: 359—380) = (Chopra 1961: 268 to 274 & 1962: 93—102, Jit and Singh 1971: 1—27), but notable mention must be made of some of these either for exhibiting new tendencies in research methodology or/and for taking a large series of measurements (Nishizuka 1926: 1—90, Haeusermann 1926: 465—474, Straus 1927: 1—28 and Reynolds 1947: 165—200) as well as of equal significance by others who have assessed the qualitative and quantitative change in prehistoric male and female pelves from Turkey (Angel 1946: 70—74) and the Peruvian highlands (MacCurdy 1923: 282—283).

PROBLEM & MATERIAL

The present cross-sectional study of a sample of 413 Panjabi speaking females ($5^1/_2$ to $17^1/_2$ yr.) belonging to the Khatri—Arora mixed Mendelian breeding group residing in Delhi, since at least 1947 if not earlier, aims at assessing effects of age-changes in four entirely fresh and another four slightly modified versions of pelvic measurements in use today. Differences between pubescent and non-pubescent (or pre-pubescent) females in this context have also been investigated. Correlation matrices between chronological age and the eight pelvic measurements have also been prepared.

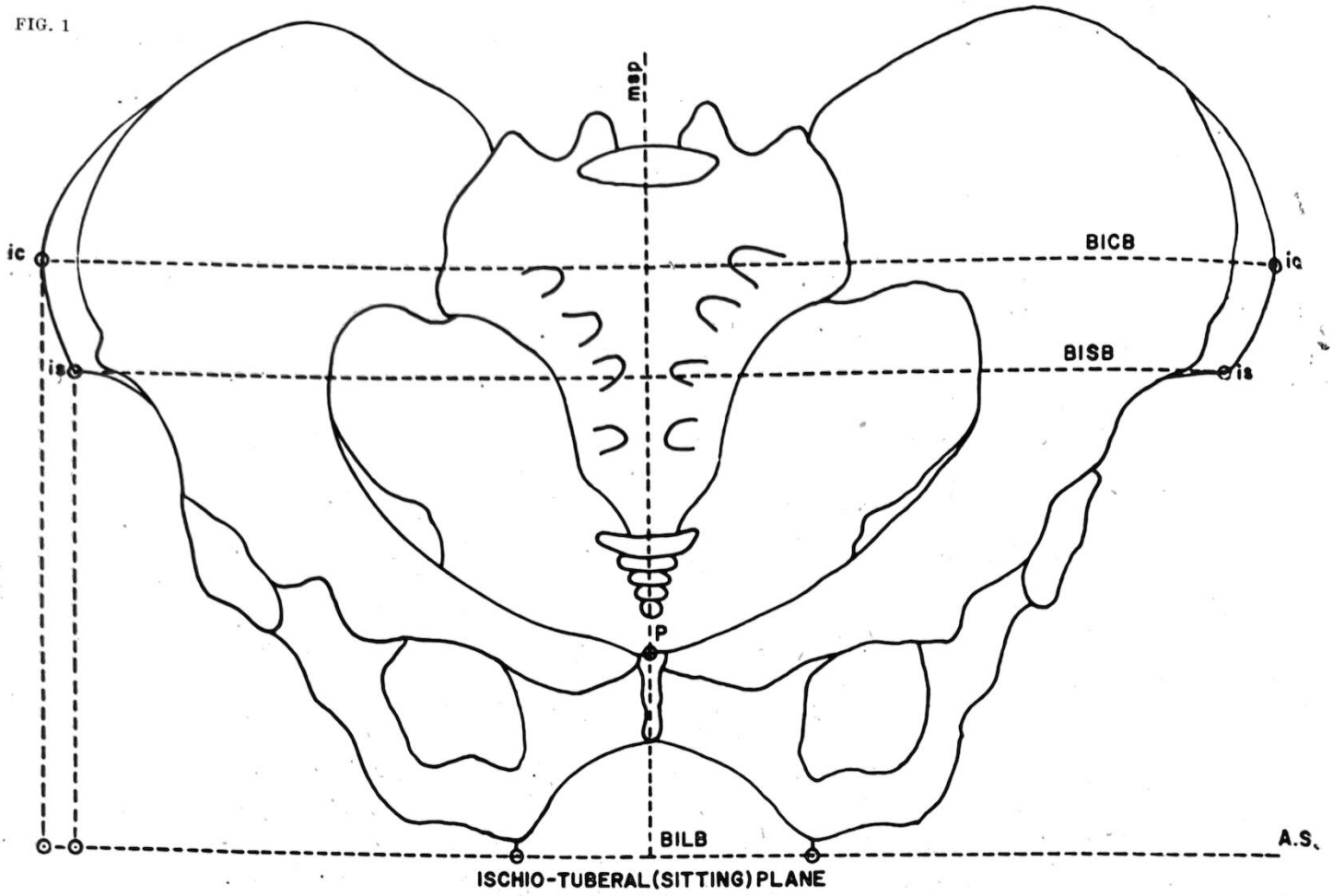
METHODS

As will become clear from the definitions of pelvic measurements listed below in the Martin method (Martin 1928), the subject is asked to sit on a stool kept by the wallside with the subject's posteriormost points of pair of buttocks touching the vertical wall with moderate pressure so as to ensure not only the pair of buttocks touching the wall-vertical but also a standardised procedure in recording the three projective pelvic depths *(see Fig. 2)* from iliospinale, iliocristale and the pubic point symphysion as well as two pelvic heigts and two pelvic breadths in this position.

Since fairly reliable dates of birth are available for each girl in the Delhi schools from the school-records (the first registration of a child in a school being conditional to the submission of a municipal corporation birth certificate), decimal system of age-recording (Tanner and Whitehouse 1966) has been used with success.

Conventional pelvic measurements, generally taken in the standard standing position, have been suitably modified so as to record the same in the standard sitting position. Measurements belonging to the "modified" category are *sitting bi-iliocristal breadth, sitting bi-iliospinal breadth, sitting right iliospinal heigth* and *sitting right iliocristal height* whereas *bi-ischial breadth, sitting buttock-iliocristal projective depth, sitting buttock-iliospinal projective depth* and *sitting buttock-pubic projective depth* are totally new measurements *(see Figs. 1 & 2).*

FIG. 1



Definitions of these measurements as given below shall justify the claim made.

DEFINITIONS OF PELVIC MEASUREMENTS

1. Sitting bi-iliocristal breadth. A *firm pressure* measurement[1] taking a straight line distance between the two iliocristalia (ic) in the standard sitting position. This is unlike Martin (1928) who recommends *"slight pressure"* in taking the measurement while the subject stands erect and, in this sense, it is a new measurement *(Fig. 1).* Obviously, it is different from the soft tissue measurement called (maximum) hip breadth: the difference between the two is analogous to the biacromial and bi-deltoid breadths. *Beam Compass/Sliding Caliper (600 mm range).*

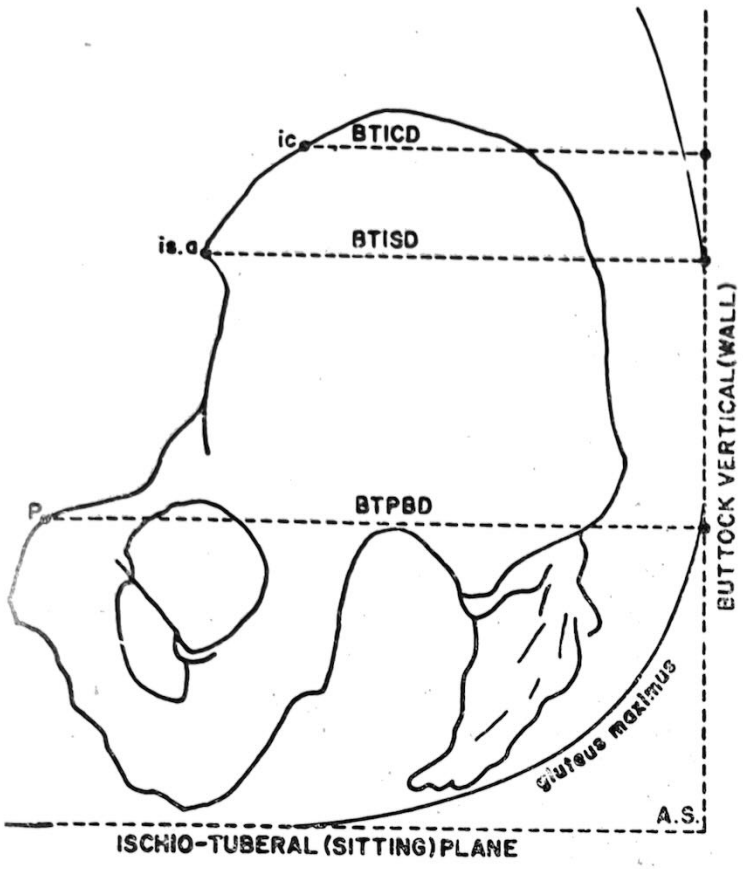
2. Sitting bi-iliospinal breadth: A *bony contact* measurement[1] taking a straight line distance between the two iliospinalia (ant. sup.) as defined by Martin (1928) but taken in the standard sitting position, not in the standing position as taken by Martin (1928) in his spinal breadth and, in this sense, it is a new measurement *(Fig. 1). Beam Compass.*

3. Sitting right iliospinal height: A *bony contact* measurement taking projective/vertical distance between the sitting ischio-tuberal plane and the right iliospinale *(ant. sup.),* i.e. it is located exactly at the *antero-superior conjunction* crossed by the median sagittal plane, not below *(Fig. 2).* The subject remains seated in the standard sitting position unlike other variations recommending this measurement in the standard standing position (e.g. Montagu cf. Garrett and Kennedy 1971). *Anthropometer's Basal Segment.*

4. Sitting right iliocristal height: A *bony contact* measurement taking the projective/vertical distance between the sitting ischio-tuberal plane and the right *iliocristale* that is defined (Martin 1928) as the most laterally placed point on the lateral border of the superior margin of the iliac crest while the subject remains seated in the

[1]) *Those who have preference for "cristal" and "spinal" breadths, may not like the expression "bi-iliocristal" and "bi-iliospinal" breadths respectively, but these are unambiguous and logical expressions, if the parallel of bi-acromial breadth is accepted. "Bi-iliocristal diameter" has been used by Newcomber and Meredith (1951:27 and 31) who define "hip-width . . . as the distance between the lateralmost point of the crest of the right ilium and the corresponding point of the left ilium, i.e., as bi-iliocristal breadth".*

FIG. 2



standard sitting position unlike Martin (1928) who takes this projective height in the standing position but equivalent to the pelvic height as taken by the *Geneva* Project (cf. Garrett and Kennedy 1971). *Anthropometer's Basal Segment.*

5. Sitting bi-ischial breadth: An entirely new measurement taking a straight line distance between the two ischio-tuberal points that actualy come in contact with the sitting plane/surface *(Fig. 1). Sliding Caliper.*

As this measurement is difficult to obtain in view of *gluteus maximus* covering the ischial tuberosities, a special approach to the measurement has been devised. The subject is asked to sit on a stool so that the sitting points of the two bony tuberosities come in contact with the posterior edge of the stool. The measurer then easily places the edge of *Sliding Caliper* on the required landmarks by palpating the same. The measurement requires certain amount of practise before getting consistency in observations between any two workers. Measurement No. 6 (Reynolds 1947. Fig. 1:172) is an approximation to this measurement but the measurement or the subject's position is not defined, similar being the case with Wilder's measurement Number 5 in pelvic girdle (Wilder 1920).

6. Sitting buttock-iliocristal projective depth: A *firm pressure* measurement taking into acount the total antero-posterior projection of the right *iliocristale* (ic) from the posteriormost point of buttocks as represented by the vertical wall since buttocks are touching the wall in the standard sitting position *(Fig. 2). Beam Compass.*

7. Sitting buttock-iliospinal projective depth: A *firm pressure* measurement taking into account the total antero-superior projection of the landmark right *iliospinale anterius superius* (is. a.s.) from the posteriormost point of buttocks as represented by the vertical wall since buttocks are touching the wall in the standard sitting position *(Fig. 2). Beam Compass.*

8. Sitting buttock-pubic symphision projective depth: A *firm pressure* measurement taking into account the total antero-posterior projection of the *antero-superior pubic point* P on the pubic bone as crossed by the mid-sagittal plane (same as symphysion/sy of Martin 1928) from the posteriormost point of buttocks as represented by the vertical wall since buttocks are touching the wall in the standard sitting position *(Fig. 2). Beam Compass.*

Following abbreviations have been used for denoting the aforelisted eight pelvic measurements in the context of economy in space occupied by Tables 1 to 3 and Appendix.

1.	Sitting bi-iliocristal breadth	BICB
2.	Sitting bi-iliospinal breadth	BISB
3.	Sitting right iliospinal height	RISH
4.	Sitting right iliocristal height	RICH
5.	Sitting bi-ischial/bi-ischiotuberal breadth	BILB
6.	Sitting buttock-iliocristal projective depth	BTICD
7.	Sitting buttock-iliospinal projective depth	BTISD
8.	Sitting buttock-pubic (or symphysion projective depth	BTPCD
	Chronological age	CA

FINDINGS & DISCUSSION

Correlation matrices of chronological age with eight biological variables of human pelvis are shown (see Appendix). All values of linear correlation coefficient (excepting one shown in italics) are significant at 5 % or 1 % or 0,1 % level of significance.

Table 1 shows the sample means of pelvic measurements in Panjabi females as well as of decimal age for 12 different age-groups. Between 11.0 and 12.0 years highest values are observed in sitting bi-iliocristal breadth, sitting bi-iliospinal breadth, sitting buttock-iliospinal projective depth, sitting right iliocristal height, sitting right iliospinal height and buttock-pubic projective depth while sitting buttock-iliospinal projective depth, sitting right iliospinal height and sitting buttock-pubic projective depth show *another comparable* highest value in each of these measurements between 13.0 and 14.0 years. Similarly, sitting buttock-iliocristal projective depth shows the highest value between

APPENDIX

Correlation Matrices Between Eight Pelvic Measurements and Chronological Age in Panjabi Females

Biological Variables	CA	BICB	BISB	RICH	RISH	BILB	BTICD	BTISD
BICB	+0.910***	—						
BISB	+0.761***	+0.748***	—					
RICM	+0.794***	+0.771***	+0.814***	—				
RISH	+0.826***	+0.838***	+0.617***	+0.807***	—			
BILB	+0.580***	+0.487***	+0.827***	+0.761***	+0.403***	—		
BTICD	+0.261**	+0.204*	+0.598***	+0.572***	+0.132	+0.877***	—	
BTISD	+0.820***	+0.825***	+0.594***	+0.731***	+0.774***	+0.415***	+0.255***	—
BTPCD	+0.800***	+0.797***	+0.818***	+0.812***	+0.707***	+0.737***	+0.527**	+0.713***

*) Significant at 5 % level **) Significant at 1 % level ***) Significant at 0.1% level.

TABLE 1

Sample Means of Chronological Age and Pelvic Measurements in Panjabi Females

Age-group (yr.)	n	CA (yr.)	$\bar{x}\alpha i$	BICB (mm.)	BISB (mm.)
5.5—(6.0)—6.5	37	5.971	$\bar{x}_i$	177.5 ± 1.1	136.5 ± 1.2
				+7.6*	+6.9
6.5—(7.0)—7.5	31	6.859	$\bar{x}_i$	185.1 ± 1.2	143.4 ± 1.6
				+6.7	+7.5
7.5—(8.0)—8.5	33	7.963	$\bar{x}_i$	191.8 ± 1.9	150.9 ± 1.9
				+4.5	+17.7
8.5—(9.0)—9.5	33	8.889	$\bar{x}_i$	196.3 ± 2.3	168.6 ± 13.0
				+10.0	—3.2
9.5—(10.0)—10.5	36	9.833	$\bar{x}_i$	206.3 ± 1.3	165.3 ± 1.6
				+12.9	+7.8
10.5—(11.0)—11.5	35	10.986	$\bar{x}_i$	219.2 ± 2.2	173.2 ± 2.7
				+16.4	+22.9
11.5—(12.0)—12.5	34	12.077	$\bar{x}_i$	235.6 ± 2.5	196.1 ± 3.0
				+12.0	+9.2
12.5—(13.0)—13.5	36	13.021	$\bar{x}_i$	247.6 ± 2.9	205.3 ± 3.0
				+12.1	—0.5
13.5—(14.0)—14.5	32	14.011	$\bar{x}_i$	259.7 ± 3.0	204.8 ± 3.0
				+3.6	+10.5
14.5—(15.0)—15.5	33	15.021	$\bar{x}_i$	263.3 ± 2.4	215.3 ± 1.6
				—0.3	+7.7
15.5—(16.0)—16.5	30	15.913	$\bar{x}_i$	263.0 ± 3.1	223.0 ± 2.6
				+16.9	—7.6
16.5—(17.0)—17.5	43	17.040	$\bar{x}$	279.9 ± 2.7	215.4 ± 2.9

*) 7.6 mm is increment between age-groups 6.0 α 7.0 yr., and so on for all other increments.

TABLE 2

Sample Means of Age and Pelvic Measurements in Pubes (P) and Non-pubes (NP) or Pre-pubes in Panjabi Females

Age-group (yr.)	n	Menarcheal Status	CA (yr.)	BICB (mm.)	BISB (mm.)
11.5—(12.0)—12.5	31	NP	12.075	235.8 ± 2.7	197.5 ± 3.1
				(+9.1)*	(+8.2)
	3	P	12.103	234.0 ± 3.5	182.3 ± 4.3
				(+19.6)	(+21.9)
12.5—(13.0)—13.5	25	NP	13.013	244.9 ± 3.1	205.7 ± 3.8
				(+4.5)	(+1.3)
	11	P	13.038	253.6 ± 6.5	204.2 ± 4.7
				(+9.5)	(—0.2)
13.5—(14.0)—14.5	8	NP	13.905	249.4 ± 6.5	207.0 ± 7.0
				(+1.0)	(+5.7)
	24	P	14.047	263.1 ± 3.1	204.0 ± 3.4
				(+3.7)	(+12.0)
14.5—(15.0)—15.5	7	NP	14.830	250.4 ± 3.7	212.7 ± 1.6
	26	P	15.073	266.8 ± 2.5	216.0 ± 2.0

*) Increment figure of (= 9.1 mm) is got by deducting 235.8 mm from 244.9 mm, respective sample means for non- or pre-pubes of the successive age-group concerned, and so on for the next.

15.0 and 16.0 years as well as between 13.0 and 14.0 years and sitting bi-ischial breadth between 14.0 and 15.0 years only. Thus, it is obvious that the sitting height and depth measurements of female pelvis show highest increases somewhat later (between the 13.0 and 15.0 years) than those of bi-iliocristal and bi-iliospinal breadths occuring comparatively earlier between ages 11.0 and 12.0 years (excluding sitting bi-ischial breadth). In other terms, *female pelves become more spacious in terms of height (excepting ic) and depth axes about two years after the major pelvic breadths*, a significant finding. Since it is a cross-sectional study, sampling fluctuations in the age-groups 9.0 and 12.0 in view of eight decrease figures, i.e. annual changes bearing a negative sign, are not altogether ruled out though major trends are indicated. This phenomenon of sudden spurts in two major pelvic breadths (= ic and is) may be truly interpreted as preponderantly an increased activity of accretionary process of bone growth, but sudden increases evidenced by the three pelvic depths (from ic, is and P) may be taken more as evidence of growth in soft tissues rather than in bone between 12.0 and 15.0 years for the obvious reason of *gluteus maximus* being involved in the measurements with ic, is and P (pubis point).

RICH (mm.)	RISM (mm.)	BILB (mm.)	BTICD (mm.)	BTISD (mm.)	BTPCD (mm.)
138.6 ± 1.3	106.3 ± 1.6	44.6 ± 0.5	90.0 ± 1.4	108.5 ± 1.6	132.0 ± 1.3
+4.4	+7.8	+0.4	+0.9	+2.7	+1.9
143.0 ± 1.5	114.1 ± 1.9	45.0 ± 0.4	90.9 ± 1.2	111.2 ± 1.2	133.9 ± 1.3
+1.3	+0.2	+3.1	−1.7	+0.3	+2.5
144.3 ± 1.5	114.3 ± 1.6	48.1 ± 0.6	89.2 ± 1.5	111.5 ± 1.7	136.4 ± 2.2
+13.5	+4.3	+16.4	+26.9(?)	+1.3	+12.2
157.8 ± 7.4	118.6 ± 2.6	64.5 ± 13.7	116.1 ± 21.6	112.8 ± 2.1	148.6 ± 6.9
+0.1	+10.7	−10.7	−19.7	+6.0	−4.3
157.9 ± 1.7	129.3 ± 1.9	53.8 ± 0.4	96.4 ± 1.6	118.8 ± 1.7	144.3 ± 1.6
+11.3	+5.4	+6.3	+2.2	+5.4	11.1
169 2 ± 1.6	134.7 ± 2.3	60.1 ± 0.6	98.6 ± 1.7	124.2 ± 1.9	155.4 ± 2.4
+11.4	+9.3	+5.6	+4.5	+9.1	+14.3
180.6 ± 2.2	144.0 ± 2.4	65.7 ± 0.6	103.1 ± 1.7	133.3 ± 2.1	169.7 ± 2.0
+0.6	−0,2	+4.4	−0.9	+2.8	+2.9
181.2 ± 1.8	143.8 ± 2.2	70.1 ± 0.5	102.3 ± 1.6	136.1 ± 2.0	172.6 ± 2.7
+6.5	+9.9	+3.6	+8.8	+9.6	+16.6
187.7 ± 2.1	153.7 ± 2.6	73.7 ± 0.6	111.1 ± 2.3	145.7 ± 2.2	189.2 ± 2.9
+7.8	+2.5	+7.2	−1.4	+2.2	−6.1
195.5 ± 1.5	156.2 ± 2.0	80.9 ± 0.6	109.7 ± 1.8	147.9 ± 2.2	183.1 ± 2.8
+1.2	+5.9	+2.3	0.0	−1.2	+7.9
196.7 ± 1.9	162.1 ± 2.5	83.2 ± 0.9	109.7 ± 2.1	146.7 ± 2.2	191.0 ± 2.7
+6.4	+2.8	−0.7	+9.1	+6.5	+5.1
203.1 ± 1.9	164.9 ± 2.3	82.5 ± 0.6	118.8 ± 1.2	153.2 ± 1.5	196.1 ± 2.2

RICH (mm.)	RISH (mm.)	BILB (mm.)	BTICD (mm.)	BTISD (mm.)	BTPCD (mm.)
178.9 ± 2.1	142.4 ± 2.4	65.4 ± 0.6	103.2 ± 1.9	133.0 ± 2.3	168.4 ± 2.0
(+1.7)	(−0.2)	(+4.4)	(−1.2)	(+1.1)	(−1.4)
198.0 ± 7.0	161.0 ± 6.5	68.3 ± 2.4	102.3 ± 5.0	136.7 ± 0.3	183.0 ± 2.7
(−15.5)	(−13.5)	(+2.7)	(+0.5)	(+3.9)	(+2.3)
180.6 ± 2.2	142.2 ± 2.6	69.8 ± 0.6	102.0 ± 2.2	134.1 ± 2.4	167.0 ± 2.4
(+3.3)	(+5.7)	(+4.7)	(+12.4)	+(15.0)	(+24.1)
182.5 ± 3.4	147.5 ± 4.1	71.0 ± 1.0	102.8 ± 1.5	140.6 ± 3.1	185.3 ± 5.6
(+6.5)	(+8.1)	(+2.5)	(+7.2)	(+3.9)	(+3.2)
183.9 ± 3.2	147.9 ± 4.5	74.5 ± 0.8	114.4 ± 5.5	149.1 ± 3.5	191.1 ± 4.4
(+13.5)	(+4.0)	(+3.4)	(−9.7)	(−1,8)	(−23.2)
189.0 ± 2.6	155.6 ± 3.1	73.5 ± 0.8	110.0 ± 2.6	144.5 ± 2.6	188.5 ± 3.6
(+6.0)	(+1.8)	(+8.2)	(+1.0)	(+3.6)	(−1.3)
197.4 ± 4.5	151.9 ± 5.1	77.9 ± 1.1	104.7 ± 3.0	147.3 ± 6.4	167.9 ± 4.9
195.0 ± 1.6	157.4 ± 2.0	81.7 ± 0.6	111.0 ± 2.1	148.1 ± 2.3	187.2 ± 2.8

TABLE 3

Values of Students' t-Test in Sample Means of Pubes and Non-pubes/Pre-Pubes in Panjabi Females

Age-group (yr.)	BICB (mm.)	BISB (mm.)	RICH (mm.)	RISH (mm.)	BILB (mm.)	BTICD (mm.)	BTISD (mm.)	BTPCD (mm.)
11.5—(12.0)—12.5	0.206	1.472	2.701*	2.352*	1.479	0.134	0.497	2.245*
12.5—(13.0)—13.5	1.385	0.228	0.481	1.113	1.159	0.219	1.577	3.546*
13.5—(14.0)—14.5	2.134*	0.423	1.043	1.283	0.704	0.808	0.923	0.393
14.4—(15.0)—15.5	3.118*	0.828	0.641	1.156	3.084*	1.470	0.151	3.223*

*P < 0.05

Much the same observations apply when the pubescent/prepubescent differentiation is used to consider the sample *(Table 2)* with isolated exceptions. Most sample means of pelvic measurements (24/32) between pubescent and pre-pubescent females bear non-significant differences, 8/32 out of them showing significant differences as listed below:

12.0 yr. age-group: Sitting right iliocristal height
Sitting right iliospinal height
Sitting buttock-pubic projective depth
13.0 yr. age-group: Sitting bi-iliocristal breadth
14.0 yr. age-group: Sitting bi-iliocristal breadth
15.0 yr. age-group: Sitting bi-ischial breadth
Sitting buttock-pubic projective depth

Obviously, sitting heights (z-axis) of female pelvis from iliocristale and iliospinale on the ischio--tuberal horizontal line are the first (12.0 yr.) to show significant differences followed by sitting buttock--pubic projective depth (12.0, 13.0 and 15.0 yr.) between pubescent and pre-pubescent Panjabi females. A notable feature is that the sitting buttock--pubic projective depth along y-axis shows significant differences in three of four age-groups involved and this may thus be a genuine difference between the pubescent and pre-pubescent females.

However, lest one gains a quick/superficial impression from 24/32 non-significant differences *(Table 3)* that the pubescent status of a female is largely unrelated with or/and is independent of growth of human female pelvis as an isolated anatomical structure, it may be mentioned that this hypothesis needs the proof where the partition between pubescent and pre-pubescent females does not rest only on such small numbers as 3 (pubes), 11 (pubes), 8 (pre-pubes) and 7 (pre-pubes) in the four age-groups of 12.0 to 15.0 years (see *Tables 2* and *3).*

ABSTRACT

Eight pelvic measurements have been measured on 413 Delhi based Panjabi-speaking girls belonging to a single breeding group. Four of the measurements are entirely new while another four are slightly modified versions of the existing ones.

The highest values have been observed at different ages (between 11.0—15.0 yr) for different measurements, including some that show two comparable peaks that are really difficult to explain for the present.

Female pelves seem to show highest increases along the x-axis in bi-iliocristal and bi-iliospinal breadths between 11.0 and 12.0 years i.e. two years earlier than the pelvic measurements along z (= heights) and y-axes (= depths) between 13.0 and 14.0 years.

A total of 24/32 pelvic measurements show non--significant differences between pubescent and non--pubescent females while only 8/32 show significant ones, the latter chiefly involving two heights and one depth (at 20.0 yr.), followed by one depth (at 13.0 yr.), one breadth (at 14.0 yr.) and lastly, two breadths and one depth (at 15.0 yr.). However, the hypothesis that the pubescent status or lack of it is largely unrelated with or independent of the growth of human female pelvis as a whole anatomical-cum--functional structure still needs the proof with a lar--ger sample size.

All values of correlation coefficient between the eight pelvic measurements and chronological age in all their binary combinations (excepting one) are significant.

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