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Variability of Covariance of Selected Skeletal Diameters of Female in a Longitudinal Physical Training Programme

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***Abstract*—**Anthropometry helps in associating the physical properties of an individual with their racial, cultural, and psychological attributes. Numerous research studies have included different skeletal diameters as a variable. However, most of the studies suggest their inclusion describing specific characteristics/traits of the body. However, there seems to be a scarcity of literature related to the effect of any kind of longitudinal physical training on human skeletal diameters. Hence, the present investigation was conducted to study the variability of covariance of selected skeletal diameters of females in a longitudinal physical training programme. The sample for the study was 78 college going students of the University of Delhi, classified equally in three groups, i.e. viz. (a) Progressive load of training or conditioning group coded as PLT; (b) Constant load of training or non-conditioning group coded as CLT; and (c) No-load or control or sedentary group coded as NL. Collectively, mean age of the sample was 19.54±1.79 years. The randomly selected samples were given maximum consideration to maintain their homogeneity. The variables included biacromial diameter, biiliocristal diameter, bitrochantaerion diameter, humeral bicondylar, femoral bicondylar, wrist diameter, ankle diameter, and foot breadth. Multi-group repeated measure design was adopted for the experimentation. Each group was measured four times after completion of each of the three meso-cycles of six-weeks duration. The measurements were taken following the standard landmarks and procedures. Mean, standard deviation, analysis of co-variance and its post-hoc analysis were computed to analyze the data statistically. The study concluded that both the progressive and constant load of physical training bring changes in the selected skeletal diameters of females. It also reflected the increase due to growth also along with training.

***Keywords*—**Longitudinal, physical training, skeletal diameters, step progression load.

I. Introduction

ANTHROPOMETRY is branch of science that deals with the measurement of parts, proportions and composition of human body. It helps in studying the gross structure and function of body in terms of the dimensions of bone, muscle and adipose tissue [1].

Specific anthropometric profile and physical characteristics determines the success of a player in a particular sport. The broader bone dimensions or widths might be helpful in taking up more load and look better. The inclusion of different skeletal diameters in various research studies reflects its importance in improving the sports performance [2], [3].

Physical activities in the form of conditioning and/or training leads to various structural, functional and mechanical changes [4]-[7]. Different climatic conditions and exercise levels also may initiate certain changes in the perspiration levels, hemodynamics etc., which, ultimately may lead to change in the segmental mass and volume. Though the rate of change may vary from one body part to another or from one variable to another, as all the skeletal diameters are likely to be affected to a lesser extent especially at college level of students where growth does not have much influence [8], [9]. Hence, the researchers were motivated to undertake a study aimed at studying the variability of covariance of selected skeletal diameters of female sportspersons in a longitudinal physical training.

II. Procedure

A. Sample

The study was conducted on the randomly selected 78 females (Collective mean age = 19.54±1.79 years), which were classified in the following three groups as presented in Table I.

TABLE I
SAMPLE SELECTION

Group	Code	Number of Sample	Age in years (Mean ± Standard Deviation)
Progressive Load of Training or the Conditioning Group	PLT	26	19.31±1.54 years
Constant Load of Training or the No-Conditioning Group	CLT	26	20.42±1.77 years
No Load or the Control Group	NL	26	20.17±2.15 years

B. Variables

The variables selected for the study included biacromial diameter, biiliocristal diameter, bitrochantaerion diameter, humeral bicondylar, femoral bicondylar, wrist diameter, ankle diameter and foot breadth.

C. Training and Testing Protocol

The first experimental group was the Progressive Load of Training or the Conditioning Group (PLT). For this group, the load was progressively increased during the period of experimentation. i.e. step-progression loading based conditioning programme of 18-weeks duration (45 minutes per day, 5-days a week) in addition to the load given to the second

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group. The following training protocol was followed for the training and testing of this group:

TABLE II
TRAINING AND TESTING PROTOCOL

Target	Protocol-1 (0-6 weeks)	Protocol-2 (6-12 weeks)	Protocol-3 (12-18 weeks)
Heart Rate	130±10	150±10	170±10
Training Component	Flexibility & Cardio-respiratory Endurance	Muscular Endurance & Strength	Speed & Power/ Explosive Strength
Additional Load	Physical activities included in the Curriculum of Indira Gandhi Institute of Physical Education and Sports Sciences (IGIPESS)		

The second experimental group was the Constant Load of Training or the Non-Conditioning group (CLT). This group particiated in the physical activities included in the curriculum of the IGIPESS to meet the professional preparation and curricular requirement of the participating students. The third group was the No Load or the Control Group (NL). It included those students of the same age group from other colleges who did not participate in any sports or rigorous physical activity during the period of experimentation.

Each subject of the study was tested four times during the period of experimentation. First, prior to the conduct of experimentation or at the zero weeks of training, second after six-weeks of training, third after 12-weeks of training and fourth after completion of the 18-weeks of training.

D. Collection of Data

Standard anatomical landmarks and measurement procedures were followed to measure the selected variables.

E. Statistical Procedure

The data was statistically analyzed while computing Mean, Standard deviation, ANCOVA followed by its post-hoc analysis to assess the effect of longitudinal conditioning programme on selected groups (progressive load, constant load or no load group) during different stages of training and testing.

III. RESULTS AND DISCUSSION

The results have been presented in Tables I-III and illustrated vide Fig. 1.

TABLE III
DESCRIPTIVE STATISTICS OF SELECTED SKELETAL DIAMETERS OF FEMALES IN A LONGITUDINAL PHYSICAL TRAINING PROGRAMME

Variable	Group Code	N	Test-1		Test-2		Test-3		Test-4	
			Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Biacromial Diameter (cm.)	PLT	26	29.97	1.47	30.10	1.48	30.19	1.48	30.27	1.49
	CLT	26	29.77	1.24	29.84	1.24	29.92	1.22	29.98	1.21
	NL	26	30.07	1.41	30.17	1.39	30.24	1.40	30.30	1.38
Biiliocristal Diameter (cm.)	PLT	26	26.23	1.42	26.32	1.39	26.43	1.39	26.50	1.43
	CLT	26	26.33	1.40	26.40	1.39	26.45	1.41	26.52	1.42
	NL	26	26.24	1.50	26.30	1.52	26.38	1.50	26.41	1.50
Bitrochanterion Diameter (cm.)	PLT	26	30.11	1.55	30.22	1.54	30.29	1.55	30.38	1.54
	CLT	26	29.68	1.30	29.74	1.29	29.81	1.27	29.85	1.29
	NL	26	30.39	1.67	30.46	1.67	30.54	1.71	30.59	1.70
Humeral Bicondylar (cm.)	PLT	26	5.15	0.23	5.18	0.22	5.26	0.23	5.31	0.23
	CLT	26	5.00	0.33	5.03	0.33	5.08	0.33	5.09	0.34
	NL	26	4.96	0.31	4.99	0.29	5.05	0.29	5.08	0.31
Femoral Bicondylar (cm.)	PLT	26	8.40	0.27	8.47	0.26	8.54	0.28	8.61	0.27
	CLT	26	8.28	0.31	8.31	0.32	8.35	0.32	8.38	0.33
	NL	26	8.07	0.31	8.09	0.31	8.18	0.31	8.20	0.32
Wrist Diameter (cm.)	PLT	26	4.82	0.25	4.87	0.24	4.94	0.24	5.01	0.25
	CLT	26	4.78	0.31	4.82	0.30	4.88	0.30	4.88	0.30
	NL	26	4.71	0.21	4.73	0.20	4.80	0.20	4.83	0.20
Ankle Diameter (cm.)	PLT	26	6.09	0.25	6.15	0.26	6.23	0.24	6.28	0.25
	CLT	26	6.06	0.33	6.10	0.32	6.13	0.32	6.17	0.31
	NL	26	6.07	0.33	6.10	0.32	6.18	0.32	6.22	0.32
Foot Breadth (cm.)	PLT	26	8.39	0.23	8.45	0.21	8.53	0.20	8.62	0.21
	CLT	26	8.24	0.35	8.27	0.34	8.31	0.34	8.33	0.35
	NL	26	8.42	0.35	8.45	0.34	8.55	0.34	8.58	0.34

PLT = Progressive Load Training (Conditioning Group); CLT = Constant Load Training (Non-Conditioning Group); NL = No Load (Sedentary Group)

The analysis of data in Table III, illustrated vide Fig.1 pertaining to the descriptive statistics of selected diameters of females in a longitudinal physical training programme demonstrates that that the mean values of all the selected four variables observed an increasing trend among all the selected groups.

Table IV pertaining to the analysis of co-variance of selected diameters of females in a longitudinal physical training programme exhibits the F-ratios for the adjusted post-test means for comparison among different groups namely progressive load group (PLT), constant load group (CLT) and no-load group (NL) for different stages of conditioning

programme viz. stage-1 (difference between zero to 6-weeks), stage-2 (difference between zero to 12-weeks), stage-3 (difference between zero to 18-weeks), stage-4 (difference between 6 to 12 weeks), stage-5 (difference between 6 to 18 weeks) and stage-6 (difference between 12 to 18 weeks). The calculated 'F-ratios' significant at .05 level are marked with * symbol.

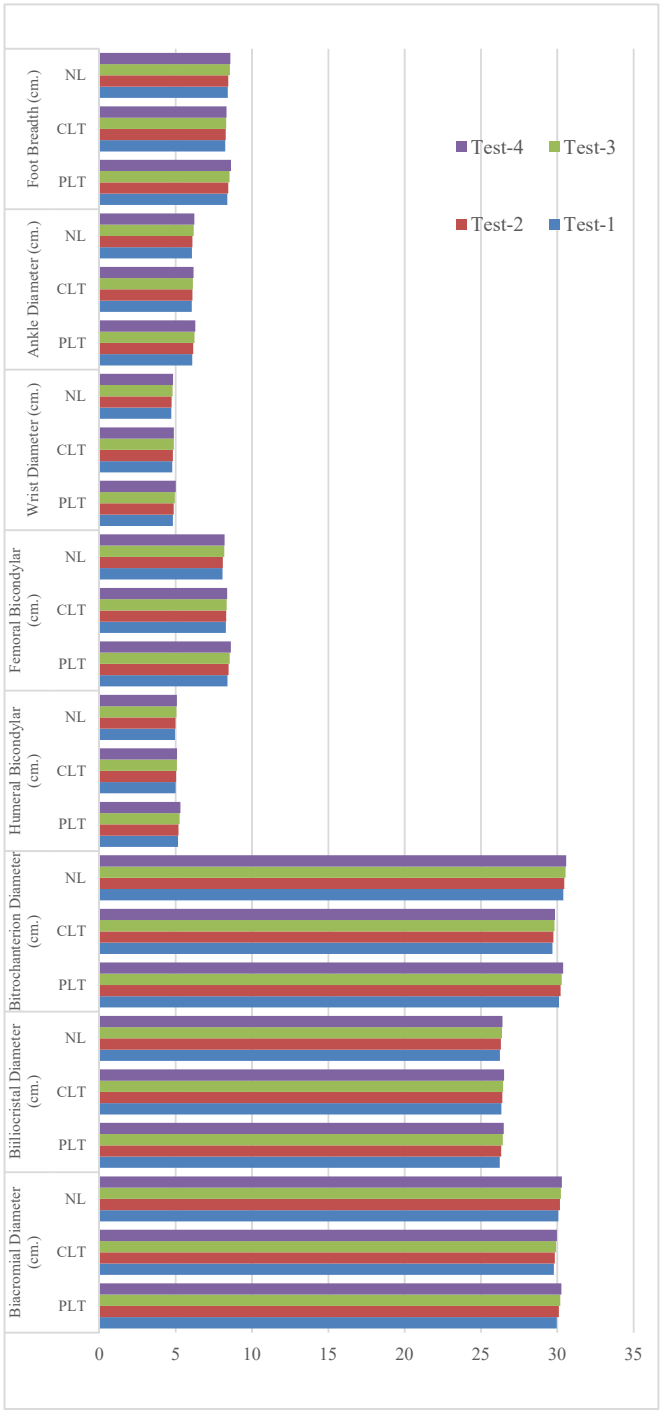

Fig. 1 Comparison of Selected Diameters of Females in a Longitudinal Physical Training Programme

TABLE IV
ANALYSIS OF COVARIANCE OF SELECTED DIAMETERS OF FEMALES IN A LONGITUDINAL PHYSICAL TRAINING PROGRAMME

Variable	Difference of Means					
	Stage-1 (0-6 weeks)	Stage-2 (0-12 weeks)	Stage-3 (0-18 weeks)	Stage-4 (6-12 weeks)	Stage-5 (6-18 weeks)	Stage-6 (12-18 weeks)
Biacromial Diameter	3.85*	2.01	3.31*	0.18	0.75	0.88
Biiliocristal Diameter	0.46	3.71*	6.51*	3.43*	3.89*	2.69
Bitrochanterion Diameter	3.86*	1.39	7.18*	0.08	1.80	4.95*
Humeral Bicondylar	0.39	2.98	7.90*	1.49	5.09*	4.26*
Femoral Bicondylar	6.66*	8.90*	14.76*	3.884*	6.90*	4.00*
Wrist Diameter	1.97	2.81	13.74*	0.84	12.06*	9.27*
Ankle Diameter	2.94	10.52*	10.94*	4.97*	5.47*	1.13
Foot Breadth	4.25*	15.01*	38.36*	9.30*	26.59*	10.57*

*Significant at .05 level

The findings demonstrate that mean difference was statistically significant for the biacromial diameter in stages 1 & 3 and insignificant in stages 2, 4, 5 & 6. For biiliocristal diameter, the F-ratio was statistically significant in stages 2, 3, 4 & 5 and insignificant in stages 1 & 6. Bitrochanterion Diameter observed statistically significant difference at stages 1, 3 & 6 however, it was insignificant at stages 2, 4, & 5. Humeral bicondylar observed statistically significant difference in stages 3, 5 & 6 and remained insignificant during stages 1, 2 & 4. Femoral bicondylar observed statistically significant F-ratios during all the stages of experimentation. Wrist diameter observed statistically significant mean difference in stages 3, 5 & 6 and remained insignificant in stages 1 & 2. The F-ratio was statistically significant for ankle diameter in stages 2, 3, 4 & 5, which was insignificant in stages 1 & 6. The foot breadth observed statistically significant F-ratios during all the stages of experimentation.

To find out which of the groups significantly differed in the adjusted post means, the post-hoc t-test for paired mean comparison was applied where F-ratio was found to be statistically significant, and results pertaining to the same is presented in Table III.

The analysis of data in Table V displays that both the progressive load and constant load of training bring changes in various skeletal diameters of females. The changes are described below:

- The progressive load of conditioning programme of 18-weeks duration had the following effects (difference between PLT and CLT):
  - Insignificant changes in biacromial diameter and biiliocristal diameter during all the stages of experimentation.
  - Significant changes in bitrochanterion diameter in stage 3 and insignificant change in stages 1, 2, 4, 5 & 6 of training.
  - Significant changes in humeral bicondylar in stages 3 & 5 and insignificant changes in stages 1, 2, 4 & 6 of training.
  - Significant changes in femoral bicondylar in stages 1, 2, 3 & 5 and insignificant changes in stages 4 & 6 of training.

- Significant changes in wrist diameter in stages 3, 5 & 6 and insignificant changes in stages 1, 2 & 4 of training.
- Significant changes in ankle diameter at stage 3 & 5 and insignificant changes in stages 1, 2, 4 & 6 of training.
- Significant changes in foot breadth in all the stages except stage-1 i.e. zero to six weeks of training, where it was insignificant.
- 6-weeks of conditioning observed insignificant change in all the selected diameters except femoral bicondylar, where it was significant.
- 12-weeks of conditioning observed insignificant changes in femoral bicondylar and foot breadth and remained insignificant for all other variables.
- 18-weeks of conditioning observed significant changes in bitrochanterion diameter, humeral bicondylar, femoral bicondylar, wrist diameter, ankle diameter and foot breadth and remained insignificant for biacromial and biiliocristal diameter.
- The intermittent stages of testing reveals that the Stage-4 i.e. 6-12 weeks had significant effect only on foot breadth. Stage-5 i.e. 12-18 weeks of training had significant change in the humeral bicondylar, femoral bicondylar, wrist diameter, ankle diameter and foot breadth and insignificant effect on biacromial, biiliocristal and bitrochanterion diameters. At stage-6 i.e. 12-18 weeks of training, only wrist diameter and foot breadth were found to be statistically significant, and all other variables remained insignificant.

- The combination of progressive load (conditioning programme of 18-weeks) and constant load of training (regular physical education programme of IGIPESS) observed the following effects (difference between PLT and NL):
- Insignificant changes in biacromial diameter, bitrochanterian diameter and humeral bicondylar during all the stages of experimentation.
- Significant changes in biiliocristal diameter and wrist diameter in stage-3 and insignificant change in all other stages of training.
- Significant changes in femoral bicondylar at stages 1 & 3 insignificant changes in stages 2, 4, 5 & 6 of training.
- Significant changes in ankle diameter at stage 2 only and insignificant changes in all other stages.

TABLE V
POST-HOC COMPARISON OF ADJUSTED POST MEANS OF SELECTED DIAMETERS OF FEMALES IN A LONGITUDINAL PHYSICAL TRAINING PROGRAMME

Variable	Mean Difference between PLT and CLT					
	Stage-1 (0-6 weeks)	Stage-2 (0-12 weeks)	Stage-3 (0-18 weeks)	Stage-4 (6-12 weeks)	Stage-5 (6-18 weeks)	Stage-6 (12-18 weeks)
Biacromial Diameter	0.062	0.083	0.102	0.022	0.041	0.020
Biiliocristal Diameter	0.018	0.072	0.077	0.054	0.059	0.004
Bitrochanterion Diameter	0.052	0.049	0.099*	0.004	0.047	0.051
Humeral Bicondylar	0.012	0.032	0.070*	0.022	0.061*	0.039
Femoral Bicondylar	0.048*	0.070*	0.108*	0.023	0.061*	0.040
Wrist Diameter	0.013	0.033	0.098*	0.021	0.085*	0.065*
Ankle Diameter	0.028	0.000	0.086*	0.044	0.060*	0.018
Foot Breadth	0.036	0.077*	0.139*	0.042*	0.103*	0.063*
Variable	Mean Difference between PLT and NL					
	Stage-1 (0-6 weeks)	Stage-2 (0-12 weeks)	Stage-3 (0-18 weeks)	Stage-4 (6-12 weeks)	Stage-5 (6-18 weeks)	Stage-6 (12-18 weeks)
Biacromial Diameter	0.038	0.057	0.083	0.019	0.045	0.027
Biiliocristal Diameter	0.023	0.054	0.092*	0.031	0.069	0.038
Bitrochanterion Diameter	0.037	0.028	0.070	0.010	0.032	0.042
Humeral Bicondylar	0.012	0.033	0.043	0.025	0.036	0.011
Femoral Bicondylar	0.051*	0.029	0.074*	0.018	0.025	0.050
Wrist Diameter	0.028	0.033	0.070*	0.008	0.043	0.038
Ankle Diameter	0.035	0.071*	0.055	0.003	0.021	0.024
Foot Breadth	0.027	0.013	0.065*	0.014	0.038	0.052*
Variable	Mean Difference between CLT and NL					
	Stage-1 (0-6 weeks)	Stage-2 (0-12 weeks)	Stage-3 (0-18 weeks)	Stage-4 (6-12 weeks)	Stage-5 (6-18 weeks)	Stage-6 (12-18 weeks)
Biacromial Diameter	0.024	0.026	0.019	0.003	0.004	0.007
Biiliocristal Diameter	0.005	0.009	0.015	0.023	0.010	0.034
Bitrochanterion Diameter	0.015	0.021	0.029	0.006	0.015	0.009
Humeral Bicondylar	0.000	0.001	0.027	0.002	0.026	0.028
Femoral Bicondylar	0.003	0.041	0.034	0.042	0.036	0.009
Wrist Diameter	0.015	0.000	0.028	0.013	0.042	0.027
Ankle Diameter	0.007	0.071*	0.032	0.046	0.039	0.006
Foot Breadth	0.010	0.064*	0.074*	0.056	0.065*	0.011

PLT = Progressive Load Training (Conditioning Group); CLT = Constant Load Training (Non-Conditioning Group); NL = No Load (Sedentary Group); *Significant at .05 level; NS = Not Significant at .05 level

- Significant changes in foot breadth in stage-3 & 6 and insignificant changes during the stages 1, 2, 4 & 5.
- 6-weeks of conditioning observed insignificant change in all the selected diameters except femoral bicondylar, where it was significant.
- 12-weeks of conditioning observed insignificant changes in all the variables except for the ankle diameter, which is significant.
- 18-weeks of conditioning observed significant changes in biiliocristal diameter, femoral bicondylar, wrist diameter and foot breadth.
- The intermittent stages of testing reveals that the Stage-4 i.e. 6-12 weeks and Stage-5 i.e. 12-18 weeks of training had no significant changes in all the selected variables. However, there was a significant change in the mean difference of foot breadth at Stage-6 i.e. 12-18 weeks of training. All other variables remained statistically insignificant.

- The constant load of training (regular physical education programme at IGIPESS) had the following effects (difference between CLT and NL) :

- Insignificant changes in biacromial diameter, biiliocristal diameter, bitrochanterion diameter, humeral bicondylar, femoral bicondylar and wrist diameter during all the stages of training and testing.
- Significant changes in ankle diameter during stage 2 only, and insignificant changes during stages 1, 3, 4, 5 & 6 of training.
- Significant changes in foot breadth during stages 2, 3 & 5 and insignificant changes in stages 1, 4 & 6 of training.
- 6-weeks of conditioning had in significant effect on all the selected variables.
- 12-weeks of conditioning observed significant changes in the sitting height only; and insignificant changes in leg length, arm length, foot length and foot breadth.
- 18-weeks of conditioning observed significant changes in the sitting height, leg length, & foot breadth; and insignificant changes in arm length and foot breadth.
- The intermittent stages of testing reveals that the Stage-4 i.e. 6-12 weeks as well as stage-6 i.e. 12-18 weeks of training observed insignificant changes in all the variables; while Stage-5 i.e. 6-18 weeks of training observed significant changes in the foot breadth only.

IV. Conclusion

The study concluded that both the progressive and constant load of training had significant effect on the selected diameters of females in a longitudinal physical training programme.

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