CHAPTER II

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In this modern age, physical education programmes of any type is characterised by reforms and innovative ideas. It seems to be necessary to formulate such a review of various scholars and their works. We can bring out a deep insight and clear perspective of the overall field in such reviews. Such collected references have been presented here, in the order of importance and in sequence of merit.

The review of literature is instrumental in the selection of the topic, formulation of hypothesis and deductive reasoning, leading to the problem. It helps to get a clear idea and supports the findings with regard to the problem under study.

Debnath and Bawa\textsuperscript{2} made a study of physique body composition and somatotype of top level Indian female shot putters, discus and javeline throwers. Four Indian women shot putters, four discus throwers and six javeline throwers were anthropometrically examined and compared to Olympic participants from other countries. The authors believe that the performances of the Indian athletes are poorer than those of the other athletes because of their lower body weight.

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Mere, Wigglesworth and Edwards\(^3\) examined the "Descriptive Characteristics of NIKE Basketball Camp Participants". Physical characteristics and indices of athletic ability were assessed on 245 participants of the NIKE All American Academic Camp (1991 and 1992). The dual purpose of this testing was to characterise top male high school basketball players (mean age = 16.9 years) and to provide information to players and coaches. Athletic profiles were determined from anthropometric measures and tests evaluating power, speed, agility, strength, muscular endurance, and flexibility.

Morrow, Hoster and Nelson\(^4\) made a comparative study on women inter collegiate basketball players, volleyball players and non-athletes. They chose 330 women college students as the subject for this study. The subjects were 110 women from each of the above listed groups. Various anthropometric and performance characteristics were obtained on each subject; fat weight, lean weight, height, sitting height, arm length, biacromian and Billiac widths, 100 yard sprint time and upper and lower body isokinetic strength were measured. Athletes were found to differ significantly from non-athletes on all variables. It was indicated that basketball players had slower sprint time and greater upper and lower body strength than volleyball players.

\(^3\)V.J. La Mere, J.K. Wigglesworth and E. Edwards, "Descriptive characteristics of NIKE Basketball Participants", *Research Quarterly* (March 1993), A-23.

The results of a series of experiments carried out under heavy physical loads during the training of 96 elite cyclist, rowers and swimmers were based on the following:

(i) Complex analysis of dynamics of sensitivity, stability and speed of response of cardio-respiratory system to hypoxia, CO$_2$-H$^+$ ionic irritants; (ii) neurogenic [working] response stimuli (iii) range of changes in ventilatory, circulatory and metabolic responses and their dynamic characteristics. It was demonstrated that sensitivity, stability and speed of responses to shifts in respiratory homostasis changed during each physical load and in the process of training.

Carter and Ackland made a study on the swimmers little difference was seen in body size between sprint distance and middle distance performance but the latter had smaller skinfold thickness. This leaner composition, for the 800 and 1500 metres competitors, probably, reflected the need for economy of motion among the middle distance swimmers compared to the dominance of muscular power development for the sprinters competitors in the 25 Kilometres. Open water event (long distance) were significantly smaller than the sprinters but possessed a much greater amount of fat. In this event the extra fat would assist the swimmers. Buoyancy as well as providing thermal insulation which would protect the swimmers from hypothermia. Waterpolo players both

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male and female possess higher levels of body fat than most swimmers; however, they are generally larger in stature and body mass and as a result this extra, fat is also accompanied by greater amounts of lean tissue. In relative terms, waterpolo players possess a greater proportion of body fat than swimmers and this may provide them with added buoyancy and extra protection against body contact during the game.

Singh and Gill\textsuperscript{7} conducted a study to examine the physical and physiological characteristics of volleyball and football players and cross country runners. Members of Punjab University men volleyball team (N:12), football team (N:16) and cross country runners (N:15) were tested at the Punjab University sports complex. Age, weight and height were recorded, skinfold measurements were taken to calculate body fat and lean body weight. Under physiological variables, vital capacity, maximum breath holding capacity, maximum expiratory pressure, heart rate, systolic and diastolic blood pressure were taken and a dynamic cardio-pulmonary index was calculated. Results showed that volleyball players were taller and heavier than footballers and cross country runners and had higher cardio-pulmonary index.

Carter and Heath\textsuperscript{8} conducted a study on competitors in racquet sports on various body types. The mean somatotype for male


tennis players is 2.0 - 4.5 - 3.0, while females rate 3.5 - 3.5 - 3.0. Carter and Heath (1990) have surveyed the literature on high level female tennis players and stated that 'the somato plots of tennis players cover a fairly wide circular area, with most means (of the various groups) just to the left of the centre of the somatochart'. Male badminton players have very similar body types to male tennis players; however, squash players of both sexes were higher in mesomorphy than tennis players. Finally, it should be noted that male racquetball professionals are lower in mesomorphy and higher in endomorphy than international level performers in other racquet sports.

Bemies⁹ made a study of five outstanding track athletes. It was concluded that the runners and jumpers were found to be 2" above average height and with the arm reach an inch longer with longer legs and also with the lower leg an inch longer than other person of same height. The calf and thigh average was smaller and hip an inch narrower.

Barabas and Eiben¹⁰ conducted a study on a nation-wide cross-sectional growth and physical performance study in Hungary in the early 1980s. Their aim was to elaborate on the Hungarian national growth and physical fitness standards as well as to help the foundation of the government's ‘Youth Policy’ by scientific findings on the biological


development of the youth. Their sample (N=39,035) contains 1.5 percent of the 3-18 year old healthy boys and girls, and it is nation-wide representative for the demographic, geographic and socio-economic stratification of the population. A detailed anthropometric programme and physical performance tests were carried out and data of sexual maturation as well as data on socio-economic background of the children's family were collected. The field-work of the research project was completed in the early 1980s. The authors have published the first Hungarian National Growth Standards.

Sindhu and Singh\textsuperscript{11} have collected data on 105 Anthropometric variables among runners-specialising in long, middle and short distances, by applying standard techniques, in January, 1988, at lifters to assess, if body segment proportionately contributed to performance level. A total of 39 measurements were recorded which included lengths, circumferences, age and centre of gravity position. The results indicated few statistically significant differences between seven first class and three master olympic weight lifters. The master weight lifters were, however characterised as being stouter in body type than the first class lifters.

\textsuperscript{11}L.S. Sidhu, Jaswinder Singh ad S.P. Singh, "Physique and Body Composition of Different Categories of Runners" Abstract-cum-Souvenir (June 1989), 37-38.
Sodhi\textsuperscript{12} and et.al., made an attempt to study the kinanthropometric characteristics of the Northern Indian Junior volleyball players ranging in age from 16 to 18 years. The results are based on the cross sectional data of 90 volleyball players and 94 control subjects. The data were divided age-wise into 3 subgroups of each category.

The results of the study revealed that the volleyballers in each age group are significantly taller and heavier than the others. But amongst volleyballers the differences in height are found to be statistically non-significant between the three age groups.

The volleyballers in each age group possess considerably greater length of their trunk, broader shoulders and hips, wider humerus and femur, greater size of hand span, large chest, upper arm, thigh and calf circumferences, than the controls. The differences are found to be statistically significant in most of the cases. The skinfold show almost similar status except the biceps, triceps, and subscapular skinfolds showing significantly greater value than the controls in the 16 years age group.

In somatotype, the 16 year volleyballers are significantly more endomorphic than the controls of same age. But the other groups show similar status. In mesomorphy, the 16 and 18 years volleyballers are considerably better developed than the controls. On the other hand in ectomorphy the sporting children have lower score than the latter. On average, the volleyballers are found to be mesomorphic-ectomorph.

\textsuperscript{12}H.S. Sodhi, et.al., "Kinanthropometric Characteristics of Indian Junior Volleyball Players" \textit{Abstract-cum-Souvenir} 5 (June 1989), 44.
Sharma and Shukla\textsuperscript{13} have conducted a study on a sample of forty players; twenty in each game of hockey and football who have represented for the State in National championship including the reserves.

Thirty seven anthropometric measurement were taken on techniques suggested by Martin and Sallar (1957) and Tanner (1964). Muscle mass was calculated on the basis of formula given by Matiegka (1929). Five standardized tests administered are push-ups, sit-ups, back strength, sargent jump and grip strength.

The results indicate that there are significant differences with regard to eight out of nine measurements. The football players have significantly broad shoulders, chest circumference, humerus and femur bicondylar breaths and posses bigger thigh and calf muscles. In physical fitness tests, the football players have higher values in sit-ups leg strength, while in the remaining three tests hockey players are significantly larger and they have higher muscles mass percentage compared to football players.

Carter and Heath\textsuperscript{14} conducted a study on highly specialized and controlled contact sport, where player tasks are clearly defined. Linemen, whose task is to impede or stop the progress of the opposing team members, have high levels of endo-mesomorphy and an approximate mean somatotype rating of 5.0-7.5-1.0, from data reported


by Carter and Heath (1990). Backfield players on the other hand, who are responsible for the majority of the ball-carrying, passing and defensive tackling, need to be fast and agile. Recent computed data from Carter and Heath (1990) give an approximate body type rating of 3.0-5.5-1.5 for the latter group.

Bloomfield, Ackland and Elliott\textsuperscript{15} reported body composition information for English professional Soccer players with respect to playing position. The goal keepers had a greater sum of four skinfolds compared to others positional players, reflecting their relatively stationary role compared to the mobile nature of the other positional players, yet their average sum of skinfolds was of similar magnitude, suggesting that they possessed more lean body mass.

Karir, Kaul and Vasisht\textsuperscript{16} conducted a study on nine somatometric measurement (weight, height, sitting height biocromial diameter, bicrystal diameter, arm-length, foot length, upper arm circumference and calf circumference) and three physical performance tests (sargent jump, standing broad jump and shot put) were made on 154 urban and 150 rural Punjab school going girls ranging between 11 and 15 years. a) It was concluded that the pattern of age changes in somatometric measurements and physical performance tests, among both


urban and rural girls is generally similar, b) though no distinct socio-
geographic differences in various body dimensions are seen, the urban
girls are slightly taller, heavier and with longer linear body dimensions
than the rural girls, c) for physical performance tests, urban girls
performed somewhat better in standing broad jump and sargent jump.

Singal, Bhatnagar and Dhillon\textsuperscript{17} conducted a study on the
inter sportive differences in anthropometric measurements and body
composition of National Level Sports Women. The sample for the present
investigation consists of 100 sports women and 100 non-sports women.
The non-sports women constituted the control group. The sports women
were specialized in hockey (35), basketball (11), gymnastic (18), volleyball
(18) and athletics (18). About seventeen anthropometric measurements
have been taken on each subject. While comparing with controls, the
sports women of all games were generally taller, with bigger trunks,
broader shoulders, wider elbows, wrists, knees and ankles except
gymnasts. The circumferences were larger, the subcutaneous tissue was
lesser in all categories of players as compared to controls. The body fat
and percent body fat were lesser in players and the lean body mass and
percent lean body mass have been found to be larger in all spots women.
Inter sportive differences for sports women indicate that basketball
women were found to be taller, heavier with bigger trunk and broad
diameters than other sports women. The gymnasts were the shortest,
lighest with narrow body diameters than all the other sports women.

\textsuperscript{17}P. Singal, D.P. Bhatnagar and S. Dhillon, "Inter Sportive Differences
in Anthropometric Measurements and Body Composition of National Level Women"
Body fat, percent body fat and lean body mass have been found to be more in basketball players and percentage of lean body mass in gymnasts.

Luthra\textsuperscript{18} recognised the importance of kinanthropometry in sports performance. It was found worthwhile to compare Delhi University participating in the track and field events. Thirty female runner, nine jumper and ten throwers participated in Delhi Inter Collegiate Athletic Meet from 30th November to 1st December 1988, to whom twenty one kinanthropometric measurements were taken. One way analysis of variance was computed to compare among the three groups on the selected kinanthropometric variables, then Scheffe’s post-hoc test was applied. The conclusions were female runner, jumper and throwers significantly differed in height, weight, foot-length, bi-acromion breadth, femoral width, upper-arm girth, hip girth, calf girth, biceps skinfolds, triceps skinfold and sum of skinfold and fore upper arm length ratio.

Arm-length, upper arm length, forearm length, hand-length, leg-length, bicristal width, humeral, height, leg-length ratio and ponderal index were not found to be statistically significant among the three groups i.e. female runners, jumpers and throwers of Delhi University.

Thrower were found to be higher in mean value than runner in height, weight, bi-acromion breadth, femoral width, upper-arm girth, hip girth, calf girth, biceps skinfold, triceps skinfold, subscapular skinfold, sum of skinfold, fore-upper arm ratio and foot length.

Thrower had greater mean value than that of jumper in weight, upper-arm girth, hip girth, biceps skinfold, triceps skinfold, subscapular skinfold, sum of skinfold and fore-upper arm length ratio.

Sodhi\(^9\) conducted a study on Indian top ranking hockey players compared with Pakistani and Olympic hockey players [Sodhi, et.al., 1990]. The results indicated that the Indian players were more endomorphic with particular reference to forwards and halves. Further it was surprising to note a significantly less development of mesomorphy in the Indian and Pakistani players as compared to that of olympians. The three dimension analysis of somatotypes indicated greater value of Somatotype Attitudinal Mean of the Indian hockey players. This indicated a greater scatter of Indian players around the mean as compared to the Pakistani players and the olympians. In height, the Pakistani players showed a gradual trend of increasing height from forwards to half backs to fullbacks and goalkeepers. Earlier this trend was observed and reported in the Indian hockey players but such a trend was not observed in the above investigation. The Pakistani fullbacks seemed to be the heaviest and their goalkeepers the lightest among the two teams. The Indian players in general had the wider humerus and femur bicondylar breadth. Comparatively, the Indian players had relatively thicker skinfolds too with a general downward gradient observed from the forwards to the goalkeepers.

Ray and Khanna\textsuperscript{20} conducted a study on 60 female junior state level kho-kho players belonging to Assam, Goa, Madhyapradesh, Tamil Nadu and Andhra Pradesh. The data were collected during Interstate Junior kho-kho championship held at Bansberia, West Bengal, in January, 1989. Body weight, height, sitting height, biocromial, humerus bicondylar, bistylaid, bi-ilial, bitnochentric, femur bicondylar and bimalleocular diameter; arm, forearm, chest, abdomen, buttocks, thigh and calf circumference; upper and lower extremity length, triceps, biceps, subscapular, suprailiac, abdomen, thigh and calf skinfolds were measured in all subjects with standard techniques.

Physical performance level in 50 meters dash, grip strength, vertical jump, sit-ups and sit and reach were studied in all subjects. Body density, lean body mass and percentage of fat were calculated by Jackson, Polloc and Word (1980), Lohman et.al., (1975), and Brozok and others (1963) formula respectively. P.E.I. has been estimated by Harvard step test. It was observed that statistically significant difference exist in most of the parameters among the states.

Carter and Heath\textsuperscript{21} conducted a study on elite male basketballers on olympic and amateur players in Europe and North America. The mean somatotype of these athletes was 2.0-4.5-3.5 when data reported by Carter and Heath (1990) was computed. The spread of


the above players classified them as ectomesomorphs, ectomorph-mesomorphs and meso-ectomorphs, which seems perfectly logical when one takes into consideration the different playing positions on the court. Unfortunately almost no data are available on US National Basketball Association Professionals, who appear to be larger and slightly more ectomorphic than the above sample. When they examined female basketball players, Carter and Heath (1990) stated that 'there was a large somatotype variation in basketball, partly due to the different functions of the playing positions'. In adult samples the mean female somatotypes were to the left of the somatochart, rating a 4.0-4.0-3.0 body type.

Debnath and Bawa\(^2\) conducted a study to determine differences in physical structure among top, medium and low level performances of the National Gymnastic championships for Sub Junior Girls, below the age of 12 years, which was held at Patiala in October, 1988. Sixteen gymnastics who qualified for competition were chosen as subjects. The total sample was divided into three groups on the basis of their competitive performance i.e. Group I which consisted of the best 8 gymnasts, Group II which consisted of mediocre gymnasts and Group III which consisted of low level performances.

Age, weight, height, arm length, leg length, height index, leg length/structure index, upper arm circumference, thigh circumference, biceps skinfold, triceps, subscapular, supra-iliac, thigh and calf skinfolds were obtained on each subject to measure the physical

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structure. Students ‘t’ test was applied to find out the differences in each variable among three groups. The results of the study showed significant differences between group I and II in weight, triceps, skinfold, subscapular skinfold, supra-iliac skinfold, total of all skinfolds and competitive performance; between group I and group III in age, weight, height and arm length, leg length, upper arm circumference, thigh-circumference and in competitive performance; between group II and III in age, height, weight, arm length, leg length, upper arm circumference, thigh circumference, thigh skinfold and competitive performance. Non-significant differences are also observed in arm length, stature index and leg length, height index between group II and III, and between group I and III. It may be concluded that the low performance in case of mediocre group may be because of more amount of fat and heavy weight when compared with the top performance group.

It may also be concluded that low performance in the case of group III, may be because of their lower age and weaker physical structure when compared with the top class performers.

Kaur, Mokha and Sidhu23 conducted a study on 18 National female cyclists during 44th Senior National level cycling championship held at Punjab University, Patiala; from 12th to 19th February, 1988. The results indicated that they are of average height and do not differ from the controls, however, they are significantly heavier with well developed extremities and possess significantly less amount of body fat at various

sites. The cyclists possess significantly more amount of muscle mass than the controls. The former are significantly more mesomorphic less endomorphic and ectomorphic than the latter. Results were also compared with male cyclists.

The purpose of the study was to determine the physique and body composition of young female basketball players and to examine these variables in relation to their playing position. Eighteen members of the under seventeen England Basketball squad were measured on twenty different anthropometric sites from which somato type and body composition were calculated. Four performance measures; vertical jump, anaerobic power, right and left grip strength and laterality were measured. These variables of the basketball players grouped according to playing position. For statistical treatment of data ANOVA was computed. It was concluded that centres had the largest measures of physique and body composition followed by the forwards and then the guards. These differences were significant, particularly between the centres, and the guards. The centres were much taller, had longer, limbs, hip width and were more muscular.

Mall in his study assessed the selected physiological, anthropometric and skills in swimming contributing to success in female swimmers. Fifty female students who had undertaken general course in

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swimming from the graduate and post-graduate course of Lakshmibai National College of Physical Education, Gwalior were selected as subjects who ranged from eighteen to twenty five years. The body composition of the subjects were computed by employing skin-fold measurements at four different sites namely biceps, triceps, subscapular and suprailliac.

The data were collected for the anthropometric measurements of height, weight, arm-length, leg-length, chest girth, arm girth, thigh girth and calf girth. Statistical treatment of data included correlational analysis using zero order correlation, multiple correlation and regression equation for prediction. It was concluded that the best predictors of swimming performance had aerobic capacity, height, weight, arm-length and leg length and stroke efficiency.

Chauhan and Sharma²⁶ conducted study to investigate the relationship between selected anthropometric variables and performance of college women. Subjects were 42 females between 18 and 23 years of age. Out of the 24 anthropometric variables, only foot breadth had positive and significant correlation whereas hip girth, subscapular, thigh and calf skinfolds, body density, fat weight and lean body mass were negative and significantly correlated with performance.

Sodhi, Sandhu and Jaswinder\textsuperscript{27} studied the role of hand size in volleyball. The study was conducted on 583 subjects which include 387 volleyballers and 196 sportsmen. The sample of volleyballers consists of 95 senior level and 292 junior level players. The measurements of stature, sitting height and hand span of each subject were taken by using standard technique. The volleyballers were examined from sports hostels, sports wings, sports schools and colleges, coaching camps and various levels of competitions throughout India from June, 1989 to December, 1990. It was concluded that the stature, hand span and trunk length increase gradually, advancing age-wise as well as level-wise. With increase in age in volleyballers, the hand size gradually advances not only in size as depicted by hand span, but also expected to change in its shape and form too in order to mechanically co-op with the standard size, weight and pressure of the ball. So it appears that the hand continues adapting gradually to the balance of its change in structure and function in order to create most favourable mechanics required in game situations. Therefore greater size of hand along with longer arms help in smashing, blocking, receiving, setting-up while in offence or defence in volleyball.

Dey, Sinha and Debray\textsuperscript{28} compared the selected anthropometric and motor quality profiles of girls (8-14 years) of Eastern and North Eastern Region of India. The performance improvement during childhood and early adolescent are highly dependent on environment


and climate and further performance is being influenced by genetic and racial factors, which varies from population to population. Therefore, sports performance can be optimized by an early identification of genetically gifted children with positive genetic and somatotype markers and then by providing them suitable training and living for natural development of motor qualities based on the principles of growth and development. The present study was carried out on 700 healthy school-going girls (8-14 years) of ER and NER of India to evaluate and compare the different anthropometric and motor quality variables with the advancement of age, where major increments were recorded between 10-12 years of age in both ER and NER girls. ER girls were taller than the NER girls but NER girls were heavier than their ER counterparts except at the age of 13 years, where ER girls were found to be heavier. All the fitness scores showed positive correlation with age, height and weight but 30m run, agility run and 800m run showed significant negative relationship. Height and weight were found to be the strong predictor of strength and anaerobic performances, where adiposity as reflected by sum of skinfolds (fat%) is the weakest predictor of running, jumping and endurance performance. The percentile values of test scores indicated that NER girls are superior to ER girls in weight between 8-14 years of age but the trend in height was just reversed. The 50th percentile values of height of ER girls were found to be higher than the 75th percentile values of NER girls (10-12 years of age). The percentile value of ER and NER girls are usually for selection and comparison of physical and motor fitness status and potentiality in the particular community. From the present study it may be concluded the regional variations for different anthropometric and motor quality variables may be attributed due to
geographical variation, environmental influences, genetic factor, nutritional variation and differences in socio-economic status of ER and NER girls.

Nutter and Thorland\textsuperscript{29} conducted the study and examined the relative importance of body size and composition as determinates of individual difference in isokinetic leg extension strength in young adult males, performing at slow moderate and fast speeds. The subjects were 31 males between the ages of 19 and 29 years, who were not participating in weight training programmes. Low to moderate correlations were found between isokinetic strength and body size or body composition measurements. At each speed, similar proportions of the variance in peak torque values were accounted for by lean body weight (23-30\%) and thigh volume (20-37\%). However, body weight, often suggested as the best reference standard for equalizing strength scores, also accounted for only 13-24\% of the variance in peak torque values at each of the speeds tested. The moderate correlations reported in this study do not support the use of body size and composition measurements as a mean of adjusting strength values.

Siders, Bolonchuka and Lukaski\textsuperscript{30} conducted a study on fifty three collegiate athletes (18 female and 35 male) recruited from university basketball, football, swimming and wrestling team rosters. Body

\textsuperscript{29}June Nutter and William G. Thorland, "Body Composition and Anthropometric Correlates of Isokinetic Leg Extension Strength of Young Adult Males", \textit{Research Quarterly for Exercise and Sport} 58 (1987), 47-51.

composition were estimated before the beginning and before the end of sport seasons by using hydrodensitometry to determine the effect of participation in competitive sport seasons on the body composition of collegiate athletes. ANOVAs applied to the estimates of body composition indicated that the interaction of sport team by season was significant for body weight, $F(5,47) = 3.2$, $p<0.05$; fat weight, $F(5,47) = 2.4$, $p<0.05$. Only football players did not change in body composition. Wrestlers lost the greatest amount of body weight (3.4 kg.). Female and male basketball players, female and male swimmers and wrestlers lost significant amount of body fat (2.6, 2.3, 1.8, 2.7 and 3.6 kg. respectively). Female and male swimmers gained significant amount of fat-free weight (2.0, 1.6, 2.4 and 1.8 kg. respectively). It was concluded that participation in a collegiate sport season could affect changes in fat weight and fat free weight components of body composition, but the nature of the changes are the function of the demands of the sport of participation.

Bawa and Debnath\(^3\) investigated Physical performance attributes of Indian sub junior male gymnasts from 11 to 14 years of age. The investigation was conducted to describe the physical performance attributes of the sub junior male gymnasts of 11 to 14 years' of age of National Gymnastics Championship. The second purpose of the investigation was to determine the significance of differences in various variables among high, mediocre and low performance groups. The subjects of the investigation were 36 boys who participated in the Sub

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junior National Gymnastics Championship. The subjects were divided into three groups, i.e., the high, mediocre and low performance groups on the basis of their competition performance results in Compulsory Exercise (Competition 1a) of the Sub Junior National Gymnastics Championship. Physical abilities and characteristics were assessed through a battery of tests which include age, weight, height, dips on parallel bars, pull ups on horizontal bar, standing broad jump, vertical jump, sit ups with jack knife action, 30 m sprint, trunk flexion and hip flexibility. Means and standard deviations were calculated to present the descriptive data of the sample. One way analysis of variance (ANOVA) was applied to determine the significance of differences in various variables among the High, Mediocre and Low Performance groups. Scheffe’s post-hoc test was applied to find out the significance of differences in various variables between groups. The results of the investigation have shown that high performance group (HPG) was significantly better than the mediocre performance group (MPG) in dips on parallel bars, pull ups on horizontal bar and competition performance. HPG was significantly older, heavier, taller and possessed significantly greater values for dips on parallel bars, pull ups on horizontal bar, broad jump, vertical jump, sit ups, hip flexibility and competition performance than the low performance group.

Sodhi and Rajini32 analysed the anthropometric status of elite Indian waterpoloists. Twenty two top level Indian waterpoloists aged 24.77 ± 4.75 years were examined with the help of 28 anthropometric

measurements. They were compared with a sample of non-sportmen (N=59). The present Indian waterpoloists have also been compared with the olympians. Results reveal that the present waterpoloists though almost same in age differ significantly from the control subjects of almost all the studied anthropometric variables. In body composition, the present waterpoloists were found to be heavier in muscle mass, bone mass, and fat mass than the controls and all such differences were significant at .01 levels. In somatotypes, significant differences are found in endomorphic and ectomorphic components. Notably mesomorphy of both the groups showed insignificant differences.

Indian waterpoloists when compared with olympian waterpoloists of 18/964 (N=96), 1968 (N=71), 1972 (N=176) and 1976 (N=134) are found to be lighter in weight and shorter in stature. In age they are found to be almost equal except than the waterpoloists of Mexico Olympics (1968), who are found to be significantly younger in age than Indian waterpoloists. Indian waterpoloists are also found to be significantly lesser in shoulder breadth and hip breadth than their olympic counterparts of 1968. In the somatotypes, Indian waterpoloists are found to be relatively less fatty, significantly more linear with development of mesomorphic component.

Bawa and Debnath examined the morphological characteristics and physical abilities of Indian junior male gymnasts in relation to their competition performance. The investigation was

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undertaken to determine the significance of differences in morphological characteristics and physical abilities among the male participants of the Junior National Gymnastics championship. The sample of 31 gymnasts was divided into 4 groups i.e. International Performance Group (IPG), High Performance Group (HPG), Mediocre Performance Group (MPG) and Low Performance Group (LPG) on the basis of their competition results in competition 1b (Optional Exercise) of the Junior National Championship. To assess the morphological characteristics of the subjects a few anthropometric measurements were obtained on each subject. Body density was estimated by the formula divided by Durnin and Womerslay (1974). The body density thus calculated was converted into fat percent by Siri's (1961) equation. A few physical abilities measuring tests i.e. dips on parallel bars, chin-ups on horizontal bar, bench press, vertical jump, trunk flexion, bridge up and 30 m. sprint were administered on each subject to assess the physical ability status. One way analysis of variance (ANOVA) has revealed significant differences in upper arm, fore arm, thigh and calf circumferences, arms and shoulder strength, body strength, legs power, trunk flexion and speed ability. ANOVA has also revealed non-significant differences in age, weight, height, fat percent and bridge up tests, International Performance Group (IPG) and High Performance Group (HPG) possessed significantly greater values in all circumferences and physical abilities measuring tests than the MPG and LPG. The IPG when compared with HPG as well as the MPG when compared with LPG, do not differ significantly in all the variables.
Dhara, Chatterjee and Pal examined a comparative study of physical performance and body dimension between tribal and non-tribal school students. In the present investigation body dimension and sports performance ability of tribal and non-tribal boys were evaluated. The study was conducted on 35 school boys (age range 14 to 17 years) selected from tribal and non-tribal population. Different anthropometric dimensions, e.g., height, weight, width of hip, arm girth, thigh girth, calf girth, chest girth of the boys were measured. To evaluate their sports performance different tests, viz., broad jump, shuttle run, push up, flying start and hamstring looseness were performed. Results showed that there was significant difference in body dimension between tribal and non-tribal boys except for weight arm girth and thigh girth. Tribal boys showed significantly better sports performance abilities than non-tribal students. The broad jump score and push up score were found to be significantly correlated with calf girth and arm girth respectively. It was concluded that a sports talent search programme should be undertaken among the tribal boys.

Sandhu and Sodhi conducted study on body size of 30 elite volleyball players of India and many other high ranking countries. The data were collected during a national coaching camp held in December 1988 at Netaji Subhas Southern Centre, Bangalore. Body weight and stature of each subject was measured by using standard techniques. The


height-weight ratio was obtained compared with 24 leading volleyball playing nations having played in Olympics, World Cups and other international or regional competitions. It was concluded that Indians are considerably shorter in stature and lighter in body weight. The most significant fact noticed in the present study was the ponderosity of Indian volleyball players. The latter are found to be highly lighter in relative body weight. This difference was found to be over 14kg per players when Indians are compared with volleyball players of United States reported in the study. The findings of the study have highly important implications for selection and development of talented volleyball players in India.

Mary et al., conducted a study on the effects of gender, physical activity level, age group, and test year on the mineral content of the fat-free body in children. The impact of physical activity on the growth and development of children, especially in light of their chemical immaturity, is ambiguous. There is a paucity of longitudinal data to address the influence of rigorous physical training, such as that adhered to by competitive age-group swimmers, on the magnitude and pattern of change in select parameters of body composition. Of particular interest is the mineral content of the fat-free body (MFFB), due to its clinical relevance for injury prevention and body composition assessment. Hence, the variability associated with gender (GE), physical activity level (PAL), age group (AG), and test year (TY) on the MFFB was investigated. The subjects (N=103) were categorized by GE, PAL (high, low) and AG (age

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as initial test year: 10, 11, 12, 13 years) into 16 groups. The high active subjects were age-group competitive swimmers for at least 12 months prior to testing; whereas the low active subjects did not engage in any organized physical activity program. Measures of total body water (deuterium dilution), bone mineral (single photon or dual x-ray absorptiometry) and body density (densitometry, correcting for functional residual volume) were obtained at one year interval for 4 consecutive years. Percent fat was estimated using a multicomponent model based on body density and adjusting for variability in body water and mineral content. Fat-free body was calculated by subtracting the fraction of fat from body weight $A \times 2 \times 2 \times 4 \times 4 \times (GW \times PAL \times AG \times TY)$ repeated measures analysis of variance, with TY as the within subjects factor, yielded the following significant ($p<.05$) main effects and interaction: GE, AG, TY, AG x TY. Since PAL was not significant the high and low active groups were collapsed for further analysis. MFFB was greater in the female than the males within each AG; the mean absolute (and relative) differences ranged from 192% (3.7%) in the 10 year old AG to .560% (10.3%) in the 12 year old AG. In contrast, the differences in MFFB among AGs were similar between GEs, and ranged from .01% (.2%) between the 11 and 12 year old AGs to .414% (7.6%) between the 10 and 11 year old AGs. Moreover, within the male sample, MFFB did not change significantly among TY, whereas significant differences in MFFB among TY were detected within the female sample for select AG (10, 13 years). Rigorous physical activity does not alter MFFB; however, consideration of GE and AG is essential in assessing the magnitude and pattern of change in body composition over time in children.
Slaughter et al., conducted a study on the effects of gender, physical activity level, age group and test year on select parameters of Physique in children. Theoretical consideration coupled with empirical evidence based on cross-sectional data suggest that a high level of physical activity may alter the physical growth and development of children. However the impact of stringent physical activity on the magnitude and pattern of change in the body physique of children over time is equivocal. Hence, a longitudinal design was employed to assess the variability associated with gender (GE), physical activity level (PAL), age group (AG), and test year (TY) on select parameters of physique [height (HT)] weight (WT), fat-free body (FFB), percent fat (%FAT) in children. The subjects (N=103) were categorized by GE, PAL (high, low) and AG (age at initial test year: 10, 11, 12, 13 years) into 16 groups. The high active subjects were age-group competitive swimmers for at least 12 months prior to testing; whereas the low active subjects did not engage in any organized physical activity program. Measures of HT, WT, total body water (deuterium dilution), bone mineral (SPA or QDR), and body density (densitometry, correcting for functional residual volume) were obtained at one year intervals for 4 consecutive years. Percent fat was estimated using a multicomponent model based on body density and adjusting for variability in body water and mineral content. Four (HT, WT, FFB, %FAT) 2 x 2 x 4 x 4 (GE x PAL x AG x TY) repeated measures analyses of variance, with TY as the within subjects factor, yielded the following significant (p<.05) main effects and interactions: HT (AG, TY, GE x TY, AG x TY, GE x AG x TY); WT (PAL, AG, TY, GE x TY, AG x TY, GE x AG x TY); FFB

Mary H. Slaughter, et.al., "Effects of Gender, Physical Activity Level, Age Group and Test Year on Select Parameters of Physique in Children A-4 year Longitudinal Study", Research Quarterly (March 1994), A-29.
(GE, AG, GE x AG, TY, AG x TY, GE x AG x TY); %FAT (GE, PAL, AG, TY, GE x TY) HT; WT and FFB increased across TY; however, the magnitude and pattern of increase differed between GE and among AG. For example, in males the greatest increase in FFB over 4 years was observed in the 12 year old AG (19.8 kg, 55.0%), with the greatest proportion of that increase detected between TY-3 and TY-4 (7.1 kg, 14.6%) in females the greatest difference in FFB across four years occurred in the 11 year old AG (14.5 kg, 47.7%) with the greatest proportion of that increase observed between TY-1 and TY-2 (4.1 kg, 14.9%). WT and %FAT also differed between PALs; the low active subjects were consistently heavier and fatter than their high active counterparts. Rigorous physical activity (Competitive age-group swimming) does not alter the magnitude or pattern of growth in FFB or HT in children, but it does influence %FAT, and consequently, WT.

Bemben and Bemben\textsuperscript{38} made an attempt on the comparison of body composition and bone mineral density relationships in men and women. Total bone mineral density (BMD) has been shown to be related to body weight in both men and women. However, the relations between the fat and lean components of the body with total and regional BMD, and whether these relations are similar for men and women, have not been well documented. This study examined the influence of gender on relationships between body composition measures and total and regional BMD. Male (N = 13) and female (N=12) volunteers, ranging in age from 19 to 79 years, participated in the study. Dual energy x-ray absorptiometry

\textsuperscript{38}Dbra A. Bemben and Michale G. Bemben, “Comparison of Body Composition and Bone Mineral Density Relationship in Men and Women” Research Quarterly 66 (March 1995), A-22.
(DXA) (Hologic QDR-1000/w) was used to measure total BMD, and BMD at the femoral neck, Ward's Triangle total hip, and lumbar spine sites. All bone scans were performed by the same technician and coefficients of variation were < 1.0%. Body composition was assessed by DXA (%fat, fat mass, bone-free, fat-free mass) and by underwater weighing (% fat, fat mass, fat-free mass). One way ANOVA was used to determine gender differences in bone mineral and body composition variables. Zero-order correlation coefficients were used to determine the relationships between body composition and bone mineral variables within each group (men, women). The contribution of body composition variables to BMD variables was determined by multiple regression. There was no significant (p > .05) gender effect for total BMD or for any of the regional sites. Body weight was positively related (p > .05) to total BMD in men (r = .64) and to lumbar spine BMD in women (r = .58). In men, bone-free, fat-free mass was significantly (p > .05) positively correlated to the femoral neck (r = .58), total hip (r = .58) and lumbar (r = .65) sites. Regression analyses showed bone-free fat-free mass was a significant (p > .05) predictor of total BMD and lumbar spine BMD in men. In women, bone-free, fat-free mass showed significant positive correlations with the femoral neck (r = .82, p > .01) Ward's Triangle (r = .81, p > .01), and total hip (r = .67, p > .05) and it was a significant predictor variable for these sites. %fat estimated by DXA was not significantly related to any bone mineral variables for either men or women. However, %fat from underwater weighing was negatively associated (r = .56, p > .05), with Ward's Triangle BMD in men. In summary, total BMD was not related to body weight or to body composition measures for women. Regional sites for both groups were positively related to bone-free fat-free mass, with women showing stronger
relationship than men. Based on our findings, bone-free fat-free mass may be an important predictor of hip BMD sites for women and for total BMD and lumbar spine in men.

Gethner and Malina\textsuperscript{39} conducted a study on the somatic growth, maturation, and submaximal power output of Polish Adolescents differing in activity status. The influence of training on physical growth, maturation, and aerobic power continues to attract interest and inquiry in the fields of pediatric exercise science and auxology. Few studies on this topic have utilized a longitudinal approach and Kernel regression procedures, and rarely has submaximal power output been examined. In this study, 105 Polish adolescents (53 males, 52 females) were put under scrutiny from approximately 11-19 years of age. A number of body dimensions were measured quarterly for each individual from ages 11-14, and annually or less frequently thereafter. Submaximal power output (PWC 170) was assessed semi-annually using a cycle ergometer. Adolescents who participated in sport for $>/-$ 3.0 years (17M, 19F) were considered active (A) and those who participated for $<$3.0 years, or not at all (36M, 33F) were considered not active (NA) in sport. Estimates of size attained and PWC170 at specific ages were obtained via Kernel regression procedures and submitted to sex specific repeated measures ANOVAs. Although active individuals of both sexes tended to have higher means for stature, weight, and absolute and relative PWC170 than NA individuals, none of these differences were significant, except for stature

in males. Active males were significantly taller than NA males (p = 0.04). Kernel regression estimates for age at peak height velocity (PHV) were generated and sex-specific means were calculated. Active males had an earlier mean age at PHV than NA males by 0.64 years (13.04 ± 1.06 years vs. 13.67+/− 1.29 years); however, the difference was not significant (p = 0.08). The timing of the growth sport in A and NA females was nearly identical (11.80+/− 0.72 years vs 11.88+/− 0.777 years, p = 0.70). These results support previous conclusions that training does not significantly influence growth status or maturational rate. In addition, the finding that active males were significantly taller and had a tendency towards an earlier age at PHV may imply selection for sport based on early maturity status in males.

Covington, et.al.,40 conducted study on the body composition, flexibility and selected anaerobic parameters of division I Female Softball and Volleyball Athletes. The purpose of this study was to conduct field testing to establish performance profiles for elite softball (SB) and volleyball (VB) athletes for body composition, vertical power, peak anaerobic power, anaerobic capacity, and flexibility. The subjects were female athletes (118), ages 18-23 year old (x = 19.7 ± 1.4 year) from teams competing at the National Invitational Softball Championships (n = 58) and the Great Midwestern Volleyball Championships (n=61). Body composition was estimated from 7 skinfolds. Lean body weight (SB= 51.99± 6.78, VB = 56.06 ± 4.37 kg), fat weight (SB = 15.88 ± 5.75, VB =

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14.54 ± 4.54 kg), and percentage of body fat (SB = 22.2 ± 6.06, VB = 19.59 ± 4.76%) were determined for each subject. Vertical power (kgm-s⁻¹) was calculated from performance on a vertical jump test (SB = 96.16 ± 11.7, VB = 102.11 ± 11.2). Peak anaerobic power (SB = 398.06 ± 49.0, VB = 398.25 ± 48.4W) and anaerobic capacity SB = 383.01 ± 60.0, vb = 433.97 ± 58.0W were calculated from performance during a 1 min step test. Flexibility (SB = 14.09 ± 3.0, VB = 13.53 ± 3.3 cm) was measured using a modified sit and reach protocol. One-Way factorial ANOVA was used to determine significant difference and Fischer P'LSD was used to determine the means between which significant differences existed. Significant differences were found to exist between the softball and volleyball athletes for vertical power (F(1,117) = 0.97, p<.01) and for anaerobic capacity (F(1,118) = 4.27, p<.01) performance. No significant differences existed between athletes for peak anaerobic power, flexibility, lean body weight, fat weight, or percentage of fat. These data suggest i) because performance scores differed between athletes in this study by sport, it is important to establish population specific norms, and ii) field-based performance profiles of elite athletes may provide for team selection of athletes for competition.

Dixie, Thompson, Leggett and Roorda⁴¹ conducted a study on the body composition assessment in women runners, hydostatic weighing (HW), the traditionally used criterion method for measuring body fat percentage (%BF), utilizes a two compartment (2C) model of body composition and assumes the fat-free mass density is 1.100 gcc⁻¹ in everyone. To improve the accuracy of %BF assessment, researchers have

⁴¹Dixie, I., Thompson, Sue R. Leggett, Kate Roorda, "Body Composition Assessment in Women Runners" Research Quarterly (March 1996), A-35.
developed multi-compartment models. Heymsfield et al., developed a 4 compartment (4-C) model incorporating total body water (TBW), bone mineral content, and body density (D). To compare several body composition methods, 10 women runners with the following characteristics were tested: age = 22.9 ± 5.2 years, wt = 56.2 ± 5.4 kg, ht = 167.0 ± 5.2 cm; and training 41.0 ± 10.3 miles per week. Nine subjects were Caucasian (C) and one was African-American (AA). No subjects were amenorheic. The following procedures were completed: HOW, TBW assessment using deuterium oxide, and dual energy x-ray absorptiometry (DEXA- Hologic, QDR-2000). %BF was calculated using the 2-C modal of Siri, DE x A software (Version 5.60A) TBW, and the Heymsfield 4-C modal. The % BF results (mean ± SD) of the procedures are presented below. ANOVA revealed that the techniques employed provided similar (p>0.05) %BF values for the C runners. These results were not surprising based on the normal bone density of the C runners in this sample. The values obtained for the AA runner were inconsistent. As expected, the bone density of the AA runner was higher than any C subject and was 12% above the "average" age-matched female. When the Schutte adjustment was used for calculating %BF from $D$, %BF was quite close to the 4-C value. Also, the DEXA software was in close agreement with the 4-C model in the AA subject, the 2-C model of Siri appeared to under-predict while TBW over-estimated %BF. Additional research is needed to determine appropriate methods to assess %BF in AA female athletes.

<table>
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<th>Group</th>
<th>Siri</th>
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