DU Journal of Undergraduate Research and Innovation
Volume 3, Issue 2, pp 30-42

# Physical Fitness, Body Composition and Selected Physiological Parameters of Indian University Level Male Team Game Players

Tyagi Sarita*, VanaikAnil K.*,Wasuja Monika*
*Associate Professors, Indira Gandhi Institute of Physical Education and Sports Sciences (University of Delhi), B-Block Vikaspuri, New Delhi, INDIA

ABSTRACT

The study was carried out to assess physical fitness level, body composition and selected physiological parameters of Indian University level team game players. A total of 40 male players from different games were selected from different colleges of University of Delhi. The games included viz.; Volleyball (18.3 ± 0.68 years; n=10), Basketball (19.3 ± 2.0 years; n=10), Handball (20.2 ± 2.1 years; n=10) and Hockey (19.2 ± 1.23 years; n=10). Body Fat percent (BF %) and Fat Free Mass (FFM) of these players were measured using Body Composition Analyzer (BODY STAT) which is based on the principle of bioelectrical impedance. Physical fitness variables included Cardio-Vascular Endurance (Physical Efficiency Index; PEI) through Harvard Step Test, Abdominal Strength by Sit-ups and Agility using 4X10m Shuttle Run test. The physiological variables like Blood Pressure were measured using sphygmomanometer & stethoscope. Hemoglobin and Serum Ferritin levels were tested in Pathological laboratory. Standard descriptive statistics (mean ± standard deviation) were determined and One Way Analysis of Variance (ANOVA) was tested for comparison of data among players of different teams for different games. Pearson's correlation coefficient (r) was applied to establish the relationships among various variables measured. Data was analyzed using SPSS (Statistical Package for Social Science) version 22.0. Statistical significance was tested using 95% level of probability ($p \leq 0.05$). Analysis of findings revealed that there was no significant difference in any of the body composition and physical fitness parameters studied among four groups of male athletes. The systolic and diastolic blood pressures of male team game players were found to be positively and significantly correlated with weight, body mass index and total body fat. Our study suggests the need for regular monitoring of athletes' body composition, physical fitness and physiological parameters for better performance and health benefits.

KEY WORDS: Physical Fitness, Body Composition, Team Games, Iron Status, Blood Pressure.

## INTRODUCTION

Success in any sport activity is dependent on various factors. Besides adeptness in sports related skills, physical fitness is also important for good performance. Physical fitness components are in turn affected by certain body composition and physiological parameters. Proper evaluation of these parameters and their interrelationship may provide scope for modification in these parameters through proper diet and training.

Team players of a specific game explicitly require proficiency in various physical fitness parameters like sprinting, agility, and control over fine motor skills, strength, power, speed and endurance for optimal performance. It has been emphasized that endurance as well as strength and power exercises should be implemented in conditioning programs of team game players, as they require sprint performance on one hand and throwing velocity on the other (1). Besides these skills, speed and agility drills should also be included in their conditioning programmes (1). Similarly, volleyball and basketball players are mostly tall as these sports require constant jumping and quick movements, so they need aerobic stamina along with agility and greater flexibility(2). Basketball require, improvement in characteristics of players like weight, lean body mass, strength (static as well as dynamic), flexibility and agility, which have been stressed to enhance the performance of the players in various competitions (3).

There exists a strong relationship of physical characteristics, body composition and physical fitness parameters with performance levels of athletes. A study was carried out to describe the structural and functional characteristics of elite Serbian soccer players and to make comparisons with non-elite counterparts. This study supported the fact that aerobic fitness, anaerobic power and performance results were interrelated in elite soccer (4).

Thus, the physical components of athletes largely determine their performance at all levels. Body composition is a factor that can influence athletic performance and has a bearing upon physical capabilities like endurance, speed, strength, agility and flexibility. Body composition is an important component which can improve maximal work capacity by affecting training-based alterations and some physiological parameter (5). The findings of various studies have shown that certain anthropometric and body composition characteristics are advantageous to the team game players, including greater height, greater mass (6), and greater upper body strength (7) and lower body fat percent (8). For speed and agility, athletes body muscle and perimeters are of importance and the vital negative anthropometric factor is amount of body fat (9) (10). Higher the aerobic and anaerobic power, better is the performance which is further influenced by training and some body composition components like higher lean body mass (LBM) and adequate physiological parameters like hemoglobin content. Loss of lean body mass results in loss of strength and endurance, as well as compromised immune, endocrine and musculoskeletal function (11). While higher lean body mass is associated with higher aerobic power, higher than normal body fat percentage is associated with hypertension in players (12). Players are also susceptible to loosing iron through impact with other

players causing red blood cell to be destroyed and plasma iron to be lost leading to iron deficiency. Therefore, a periodic examination of hemoglobin level along with blood pressure measurement among these players is essential in order to prevent adverse health effects (13). The evaluation of physical fitness, body composition, and certain physiological variables would give an insight into their status in the players and any deficit or alterations can be rectified for better health and performance.

## OBJECTIVE OF THE STUDY

The present study was carried out to assess the status of University level Indian male team game players belonging to Volleyball, Basketball, Handball and Hockey games with respect to anthropometric, body composition, physiological and physical fitness parameters.

## METHODOLOGY

### SAMPLE SELECTION

A total of 40 University level male players were selected from different colleges of University of Delhi, India. The team games chosen included Volleyball (18.3 ± 0.68 years; n=10), Basketball (19.3 ± 2.0 years; n=10), Handball (20.2 ± 2.1 years; n=10) and Hockey (19.2 ± 1.23 years; n=10). Only those players who had played their respective game for at least three consecutive years and followed the criterion of minimum participation at the University level of their game were selected**.** The selection of subjects was done employing purposive sampling technique.

### DATA COLLECTION

The body weight was taken using electronic weighing scale and body height was measured using anthropometer. Body Mass Index (BMI) was computed with weight (kg) and height (m) values using standard formula {BMI= Weight (kg)/height ($m^2$)}. Body Composition components including Body Fat percent (BF%) and Fat Free Mass (FFM) were measured using Body Composition Analyzer (BODYSTAT) which is based on the principle of bioelectrical impedance. Among Physical fitness variables, Cardio-vascular Endurance, Abdominal Strength and Agility were studied. Cardiovascular endurance was measured using Harvard Step Test (14) and physical fitness through Physical Efficiency Index (PEI) was calculated using the following formula:

$$\text{Physical Efficiency Index} = \frac{\text{Duration of exercise period in seconds x100}}{\text{2 x Sum of three pulse counts after exercise}}$$

Abdominal Strength was measured by Sit up Test (one Minute) and agility was measured by (4X10m) Shuttle Run. In physiological variables, Blood pressure was measured using sphygmomanometer and stethoscope while Hemoglobin and Serum Ferritin levels were tested in a Pathological laboratory.

## STATISTICAL ANALYSIS

Standard descriptive statistics (mean ± standard deviation) were determined for directly measured and derived variables. One-way analysis of variance (ANOVA) was used for the comparisons of data among players of different team games studied. Pearson's correlation coefficients were computed to establish the relationships among the various variables measured. Data was analyzed using SPSS (Statistical Package for Social Science) version 22.0. A 95% level of probability was used to indicate statistical significance ($p<0.05$).

## RESULTS

Table I depicts the physical characteristics and body composition components of the Indian University level team game players studied. The mean body weight of all team game male players was 67.45±9.78 kg, mean height was 174.45±6.02 cm and BMI value of all team game players was 22.11±2.67 kg/m$^2$**.** Table I also shows the body composition profile of male team game players.

**TABLE-I: Physical Characteristics and Body Composition of University Level Indian Male Team Game Players**

| **VARIABLES** | **Volleyball (n=10) Mean ± SD (Range)** | **Handball (n=10) Mean ± SD (Range)** | **Hockey (n=10) Mean ± SD (Range)** | **Basketball (n=10) Mean ± SD (Range)** | **Total (n=40) Mean ± SD (Range)** |
|---|---|---|---|---|---|
| WEIGHT (kg) | 66.16 ±10.61 (48.1-81.5) | 69.87±10.02 (57.2-86.9) | 66.02±8.49 (53.4-81.3) | 67.75±10.92 (51.7-86.3) | 67.45±9.78 (48.1-86.9) |
| HEIGHT (cm) | 172.4±7.62 (159-182) | 174.62±5.10 (168-183) | 174.45±5.42 (167-183) | 176.35±5.91 (170-189.5) | 174.45 ±6.02 (159-189.5) |
| BODY MASS INDEX (kg/m$^2$) | 22.22±3.09 (17.40-26.60) | 22.89±2.83 (19.80-29) | 21.67±2.61 (16.80-24.8) | 21.67±2.35 (17.9-24.5) | 22.11±2.67 (16.80-29.0) |
| FAT FREE MASS (kg) | 51.82±7.30 (40.4-59.9) | 56.51±6.03 (47.2-64.8) | 53.18±4.88 (45.1-61.6) | 54.37±6.15 (46.1-66.5) | 53.97±6.16 (40.4-66.5) |
| BODY FAT (%) | 21.08±3.92 (14.5-26.5) | 20.23±3.61 (15.5-27.1) | 19.05±4.19 (10.8-24.3) | 19.04±5.4 (10.7-27.8) | 19.85±4.28 (10.7-27.8) |

No significant differences were observed in any of the body composition components among male team game players. The mean Fat Free Mass (FFM) was **53.97±6.16 kg and** mean Body Fat Percent (BF%) was **19.85±4.28.** Distribution of subjects according to BMI classification (15) is presented in Figure I.

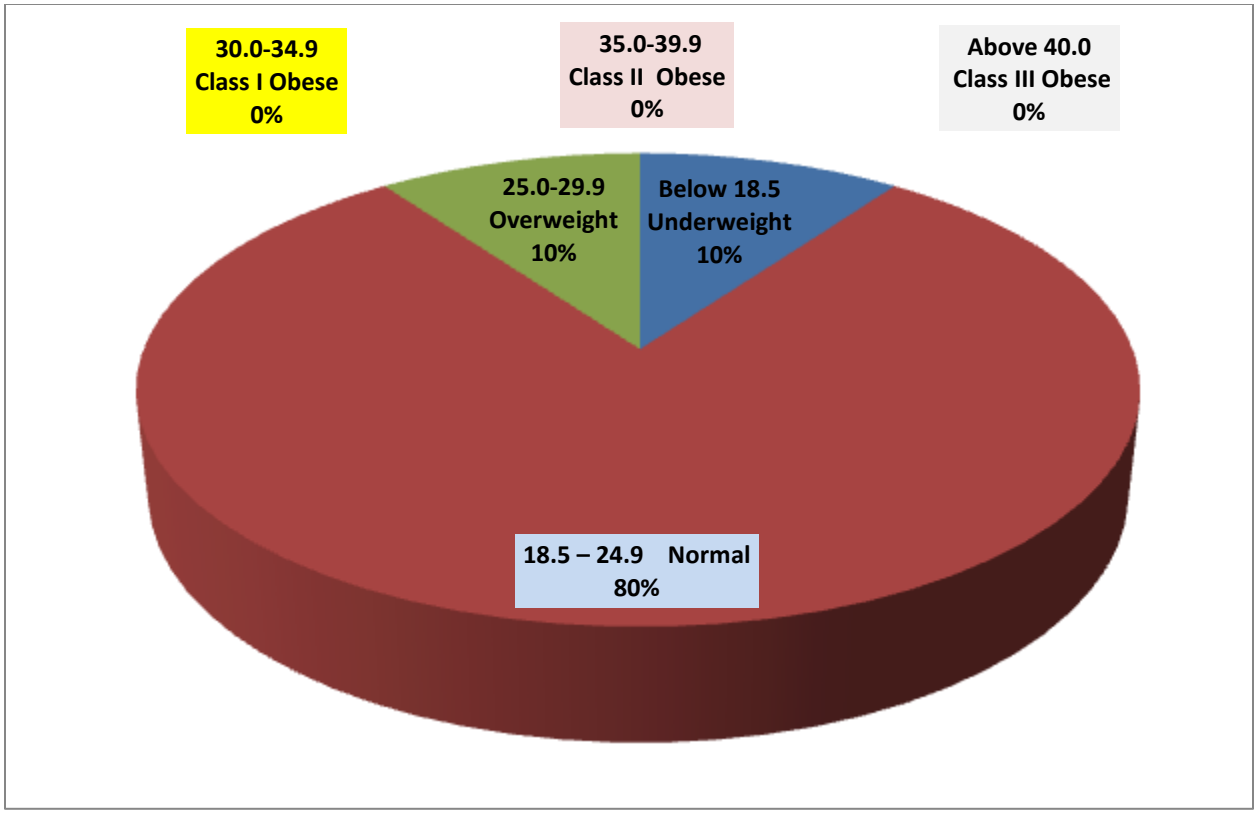


**Figure-I: Distribution of Players according to BMI classification (WHO)**

**TABLE-II: Physical Fitness Parameters of Male Team Game Players (MEAN ± SD)**

| VARIABLES | Volleyball (n=10) Mean ± SD (Range) | Handball (n=10) Mean ± SD (Range) | Hockey (n=10) Mean ± SD (Range) | Basketball (n=10) Mean ± SD (Range) | Total (n=40) Mean ± SD (Range) |
|---|---|---|---|---|---|
| SIT UPS (No./MIN) | 40.60±9.57 (17-55) | 46.30±10.62 (34-64) | 38.6±7.38 (23-49) | 35.6±11.99 (21-60) | 40.27±10.42 (17-64) |
| SHUTTLE RUN(SEC) | 10.98±1.15 (9.98-13.08) | 10.66±0.53 (9.81-11.59) | 10.19±0.43 (9.69-11.0) | 10.71±0.92 (9.56-12.30) | 10.63±0.83 (9.56-13.08) |
| PHYSICAL EFFICENCY INDEX (PEI) | 89.16±9.79 (73.94-105.60) | 95.89±8.46 (83.79-110.29) | 90.34±11.90 (77.31-112.78) | 88.65±8.73 (77.31-101.35) | 91.01±9.87 (73.93-112.78) |

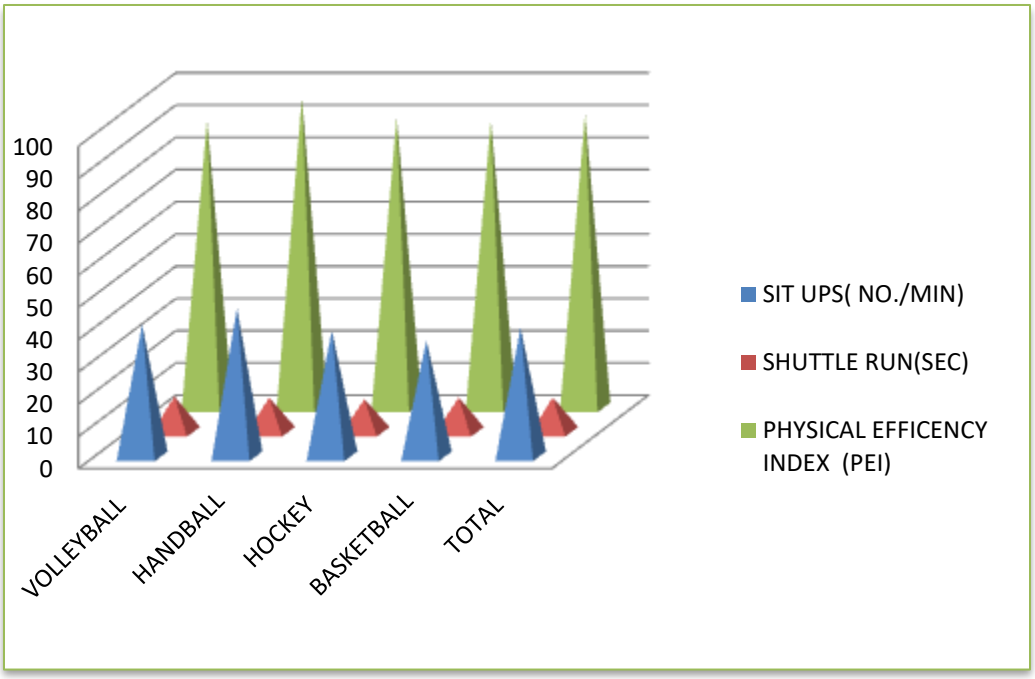


**Figure-II: Comparison of Physical Fitness Parameters of Team Game Players**

The physical fitness parameters assessed in the present study included sit-ups for abdominal strength, Harvard step test for cardio-respiratory endurance through computed Physical Efficiency Index (PEI) and shuttle run for agility. One-way ANOVA revealed no significant differences in physical fitness parameters among four groups of male athletes studied. Mean Sit-up count was 40.27±10.42 per minute, mean Shuttle run timing was 10.63±0.83 sec and mean PEI score was 91.01±9.87 (Table II)**.**The distribution of male team game players according to PEI classification (Table III) revealed that maximum number of subjects from all team games had excellent (35%), good (42.5%), average (22.5 %) PEI scores and none had below average or poor PEI scores.

**TABLE-III: Distribution of Subjects According to Physical Efficiency Index Classification (PEI)**

| PHYSICAL EFFICIENCY INDEX (PEI) | Volleyball (n=10) N(%) | Handball (n=10) N(%) | Hockey (n=10) N(%) | Basketball (n=10) N(%) | TOTAL (n=40) N(%) |
|---|---|---|---|---|---|
| Excellent >96 | 3(30) | 5(50) | 3(30) | 3(30) | 14(35) |
| Good 83-96 | 4(40) | 5(50) | 4(40) | 4(40) | 17(42.5) |
| Average 68-82 | 3(30) | 0 | 3(30) | 3(30) | 9(22.5) |
| Below Average 54-67 | 0 | 0 | 0 | 0 | 0 |
| Poor <54 | 0 | 0 | 0 | 0 | 0 |

**TABLE-IV: Physiological Variables of Male Team Game Players**

| VARIABLES | Volleyball (n=10) Mean ± SD (Range) | Handball (n=10) Mean ± SD (Range) | Hockey (n=10) Mean ± SD (Range) | Basketball (n=10) Mean ± SD (Range) | Total (n=40) Mean ± SD (Range) |
|---|---|---|---|---|---|
| SYSTOLIC BLOOD PRESSURE (mmHg) | 121.5±7.17 (112-134) | 125.4±8.18 (110-136) | 133.10±18.51 (110-164) | 128.7±7.27 (118-142) | 127.17±11.71 (110-164) |
| DIASTOLIC BLOOD PRESSURE (mmHg) | 79±6.68 (68-92) | 80.4±4.95 (70-89) | 80.70±14.44 (62-110) | 83.3±3.16 (78-87) | 80.85±8.30 (62-110) |
| HAEMOGLOBIN LEVEL (gm/dl) | 15.02±0.98 (13.6-16.9) | 14.39±0.90 (12.6-15.7) | 15.11±0.78 (14-16.4) | 14.87±0.82 (14.2-17) | 14.84±0.88 (12.6-17) |
| SERUM FERRITIN LEVELS (ng/ml) | 55.20±38.95 (12-144.30) | 49.76±19.76 (23.90-83.90) | 70.9±63.05 (15.3-216.10) | 60.78±25.81 (24-103.6) | 59.16±39.67 (12.0-216.10) |

Table IV displays that mean systolic blood pressure (SBP) for all team games was 127.17±11.71 mmHg and mean diastolic blood pressure (DBP) of these players was 80.85±8.30 mmHg. The distribution of subjects according to classification for systolic and diastolic blood pressures as suggested by JNC 8 (16) (Tables V and VI) indicated a majority of the players in pre-hypertensive stage of SBP (65%) and DBP (47.5 %) across all teams. Some players had stage 1 and even stage 2 hypertension indicating need of regular monitoring and medical intervention.

**TABLE-V: Distribution of Male Team Game Players According to Classification of Systolic Blood Pressure (Age ≥18 YEARS)**

| CLASSIFICATION | Volleyball (n=10) N (%) | Handball (n=10) N(%) | Hockey (n=10) N(%) | Basketball (n=10) N(%) | Total (n=40) N(%) |
|---|---|---|---|---|---|
| NORMAL (<120mmHg) | 5(50) | 2(20) | 2(20) | 1(10) | 10(25) |
| PREHYPERTENSION (120-139 mmHg) | 5(50) | 8(80) | 5(50) | 8 (80) | 26(65) |
| STAGE 1 HYPERTENSION (140-159 mmHg) | 0(0) | 0(0) | 1(10) | 1(10) | 2(5) |
| STAGE 2 HYPERTENSION (≥ 160 mmHg) | 0 (0) | 0 (0) | 2 (20) | 0 (0) | 2 (5) |

**TABLE-VI: Distribution of Male Team Game Players According to Classification of Diastolic Blood Pressure (Age ≥18 Years)**

| CLASSIFICATION | Volleyball (n=10) N(%) | Hand Ball (n=10) N(%) | Hockey (n=10) N(%) | Basket Ball (n=10) N(%) | Total (n=40) N(%) |
|---|---|---|---|---|---|
| NORMAL (<80mmHg) | 6(60) | 2(20) | 6(60) | 2(20) | 16(40) |
| PREHYPERTENSION (80-89 mmHg) | 3(30) | 8(80) | 0 (0) | 8 (80) | 19(47.5) |
| STAGE 1 HYPERTENSION (90-99 mmHg) | 1(10) | 0(0) | 3(30) | 0(0) | 04(10) |
| STAGE 2 HYPERTENSION (≥ 100 mmHg) | 0 (0) | 0 (0) | 1(10) | 0 (0) | 01(2.5) |

**TABLE-VII: Correlation of Blood Pressure with Physical Characteristics of Male Team Game Player**

| | | SYSTOLIC BLOOD PRESSURE(mmHg) | DIASTOLIC BLOOD PRESSURE (mmHg) |
|---|---|---|---|
| WEIGHT(kg) | Pearson Correlation | 0.390* | .420** |
| | Sig. (2-tailed) | 0.013 | 0.007 |
| | N | 40 | 40 |
| BODY MASS INDEX | Pearson Correlation | 0.427** | 0.292 |
| | Sig. (2-tailed) | 0.006 | 0.067 |
| | N | 40 | 40 |
| BODY FAT (%) | Pearson Correlation | 0.292 | 0.116 |
| | Sig. (2-tailed) | 0.068 | 0.475 |
| | N | 40 | 40 |
| FAT(kg) | Pearson Correlation | 0.394* | 0.443** |
| | Sig. (2-tailed) | 0.012 | 0.004 |
| | N | 40 | 40 |

**Correlation is significant at the 0.01 level (2-tailed).*Correlation is significant at the 0.05 level (2-tailed)

Table VII shows that the SBP and DBP of male team game players were positively and significantly correlated with weight (SBP-$p<0.05$; DBP-$p<0.01$), body mass index (SBP-$p<0.05$; DBP-no significant relationship was found) and total body fat (SBP-$p<0.05$; DBP-$p<0.01$).

The other physiological variables studied were Hemoglobin and Serum Ferritin levels. The mean Hemoglobin level of these players was found to be 14.84±0.88 gm/dl and mean Serum Ferritin value was 59.16±39.67 ng/ml for all game players (Table IV).

The PEI of majority of male players was above average (Table III) and the correlation of serum ferritin levels with PEI was found to be positive and significant ($p<0.05$; Table VIII).

**TABLE VIII: Coefficient of Correlation- PEI with Hemoglobin and Serum Ferritin**

| | | HAEMOGLOBIN (g/dl) | SERUM FERRITIN (ng/ml) |
|---|---|---|---|
| PHYSICAL EFFICIENCY INDEX | Pearson Correlation | -.142 | .349* |
| | Sig. (2-tailed) | .381 | .027 |
| | N | 40 | 40 |

*Correlation is significant at the 0.05 level (2-tailed).

## DISCUSSION

The performance in sports is the result of intricate relationship of physical fitness, body composition and physiological factors. The present study was conducted on Indian male University level team game players (n=40) to assess their physical fitness components, body composition parameters and selected physiological variables during peak season of competitions. The mean body weight of all team game male players was 67.45±9.78kg (Table I). Volleyball (66.16 ±10.61 kg) and hockey (66.02±8.49 kg) players had comparable mean body weights but lower than mean body weight of handball players (69.87±10.02 kg) and basketball players (67.75±10.92 kg).The mean height of all players was 174.45±6.02 cm and mean BMI value of all team game players was 22.11±2.67 kg/m2which according to BMI classification was falling in the normal category (15). Basketball players were found to be tallest (176.35±5.91 cm) in all team games studied and volleyball players were the shortest (172.4±7.62 cm). Height is a desirable physical characteristic in both basketball as well as volleyball games and is one of the important characteristics which should be seen at the time of talent selection in order to gain maximum advantage of this physical variable in the performance of athletes. In another study, the anthropometry of world-class elite handball players was studied and reported according to the playing position from men's handball World championship held in 2013.

The study shows that Asians have mean height of 185.30±5.62 cm, mean weight 87.70±9.47 kg and mean BMI of 25.52±2.34 (17). Body weight and height provide a first idea of player's morphological characteristics. In team games, differences are even found among playing positions of the players. Like in Handball, the heaviest and tallest players play the pivot followed by goalkeeper, wing, center and handed, also pivot have been reported to obtain the highest fat mass followed by goalkeeper (18).

Distribution according to BMI classification (Figure I) revealed, highest percentage (80%) of these players were in normal category followed by 10% each in overweight and underweight category. In athletes, particularly in males with higher muscle mass, BMI has inherent limitation of categorizing them in overweight category of its classification. The mean Fat Free Mass (FFM) of all groups collectively in the present study was 53.97±6.16 kg. In another study on basketball players, they were found to have skeletal muscle mass as 56.19±7.29 kg which was higher than the estimated FFM **(54.37±6.15 kg)** of basketball players of the present study (19)**.** Higher fat free mass or skeletal mass is associated with high aerobic power which is one of the desirable characteristics in team game players (20).

It was apparent from the present study that body composition has a bearing upon physical fitness parameters. Present study shows that the best performance in sit-ups (46.30±10.62) and PEI (95.89±8.46), was observed in handball players and the highest mean FFM (56.51±6.03 kg) was also found in handball players. This team had regular practice and attended camps before competitions which was reflected in their performance as well. Distribution of these subjects according to PEI score showed that the highest number of players with excellent and good scores were in handball team (Table III). With below average or poor aerobic capacity it becomes difficult to play till the end of the match with vigor, and sports performance of the player goes down. This reiterates the fact that for better performance in sports- regular practice, systematic training and overall physical fitness is indispensable. Basketball players revealed the poorest performance in the Harvard Step test (**88.65±8.73**) as compared to the players of other three games. Around 50% of the basketball players although reported to be doing regular practice, but their poor scores in PEI indicated that more specific training in cardio-respiratory component of fitness is required along with other components of physical fitness and skill-based training. Shuttle run timing which is depictive of anaerobic power and agility, was almost comparable in all four games volleyball (**10.98±1.15 sec)**, handball (**10.66±0.53 sec)**, hockey (**10.19±0.43 sec)** and basketball (**10.71±0.92 sec)**. It has been reported in the literature that in team games all strength, power and aerobic exercises should be emphasized in conditioning programmes, as these games require proficiency in physical fitness parameters like aerobic, anaerobic, speed, agility as well as in throwing velocity (1,2). Such training will have positive effects on body composition variables influencing performance.

Body composition is a modifiable factor which is greatly influenced by training and diet. Hence, regular monitoring could be a useful tool to make nutritional interventions, suggest supplement strategies and also calculate the right training workload (20). High body fat % is a limiting factor in sports performance. In the present study, mean body fat % of all team game players was 19.85±4.2% (Table-1). The BF % of basketball players (19.04±5.4 %) and hockey players (19.04±5.4 %) was comparable and was lower than the volleyball players (21.08±3.92 %) and handball players (20.23±3.61%). Generally,

for male team game players desired BF% is 6-12% (21). In the present study, the body fat % of all the teams studied was much higher than the desired percentage. Even for male non-player, the normal range of body fat percentage is 8-21%, but in the present study, most of the players had body fat percent towards the higher value of the normal range. Studies have reported body fat % of 19.01+2.34 in elite basketball players of England and BF% of 12.93±4.26 in Spanish basketball players. (20, 22)

Higher than normal body fat percentages does not only hamper sports performance but have adverse health implications in the long term. Higher than normal body fat percentage has shown the increased risk of hypertension among players (12). Mean systolic blood pressure (SBP) for all team games was 127.17±11.71 mmHg and mean diastolic blood pressures (DBP) of these players was 80.85±8.30 mmHg. This suggested that most players are in the pre-hypertensive range of blood pressure classification given by JNC 8 (16). The SBP and DBP of these players were found to be positively and significantly correlated with weight, body mass index and total body fat (Table VII). Many factors impact the systolic blood pressure, including physical, mental and medical issues. Habits such as smoking, excessive alcohol, high caffeine intake, poor sleep habits etc. can affect SBP and increase in systolic pressure stresses on heart by constricting blood vessels (23).

Another physiological variable studied in the present study was the iron status which was assessed by measuring hemoglobin and serum ferritin levels. This can have some implications on performance and health of the athletes. The study shows that athletes were found to have mean haemoglobin level of 14.84±0.88 gm/dl which was in the normal range (Table 4). Similarly mean serum ferritin value of 59.16±39.67 ng/ml for all game players was also in the normal range and only one player had low haemoglobin level while 3 (10%) players had serum ferritin levels below the normal range. Hemoglobin and serum ferritin levels may affect cardio-respiratory efficiency of the players. In this study, the PEI of majority of male players was above average and the correlation of serum ferritin levels with PEI was also found to be positive and significant ($p<0.05$; Table 8).

## CONCLUSIONS

The physical and physiological foundation of the athletes has to be strong so that they can give their best performance. The athletes should ensure that they have desirable body composition, exceptional level of required physical fitness components and related physiological parameters within the normal range. This does not only help athletes to enhance their sports performance but will also be beneficial for their long-term health. The major health concern studied in the present exercise was moderately high levels of blood pressure in some players that needs to be managed and monitored constantly. This pointed towards periodic monitoring of physiological, body composition and physical fitness levels of athletes in order to facilitate them to adopt right training methods to improve sports performance without compromising on their health issues.

ACKNOWLEDGMENTS

We acknowledge the support given by the University of Delhi under the Innovation Project Scheme (IGPE-301) that enabled us to carry out this study. We are indebted to Dr. Dhananjoy Shaw, Officiating Principal, Indira Gandhi Institute of Physical Education and Sports Sciences, University of Delhi, for his co-operation and providing necessary infrastructure and facilities for the study.

## REFERENCES

1. Ziv Gal and Lidor Ronnie (2009). Physical characteristics, physiological attributes, and on-court performances of handball players: A review. European Journal of Sport Science .9; 6.
2. Lidor Rand, Ziv G. (2010). Physical characteristics and physiological attributes of adolescent volleyball players-a review. *PediatrExerc Sci.* Feb; *22*(1):114-34.
3. Kamble Prafull,Vandana S., Daulatabad, P.S. Baji (2012). Study of anthropological parameters, body composition, strength and endurance in Basketball players. *Int J Biol Med Res*.; *3*(1): 1404-1406
4. Sergej M. Ostojić (2000). Physical and physiological characteristics of elite Serbian soccer players. FactaUniversitatis Series: Physical Education and Sport. 1: 7; 23 - 29.
5. Venkata, R. Y., Surya, K. M. V. L., Sudhakar, R. S. and Balakrishna, N. (2004). Effect of changes in body composition profile on $VO_2$ max and maximal work performance in athletes. *Journal of Exercise Physiology*, *7*: 34–39.
6. Kovaleski J, Parr R, Hornak J, Roitman J. (1980). Athletic profile of women college volleyball players. *The Physician and Sports Medicine. 8*(2):112-116.
7. Fry A, Kraemer WJ, Weseman C, Conroy B, Gordon S , Hoffman J, Maresh C. (1991). The effects of an off-season strength and conditioning program on starters and non-starters in women's intercollegiate volleyball. *Journal of Applied Sport Science Research. 5*:174-181.
8. Fleck S, Case S, Puhl J, Van-Handle P (1985). Physical and physiological characteristics of elite women volleyball players. *Canadian Journal of Applied Sport Science; 10*:122-126.
9. Armstrong N, Welsman JR. (2001). Peak oxygen uptake in relation to growth and maturation in 11- to 17-year-old humans. *Eur J Appl Physiol. 85*(6):546-51
10. Mercier B, Mercier J, Granier P, Le Gallais D, Prefaut (1992). Maximal anaerobic power: relationship to anthropometric characteristics during growth. *Int J Sports Med 13*(1): 21-26.
11. Burke Louise (2007). Practical Sports Nutrition. Human Kinetics.
12. Mushengezi Brighton and Pilly Chillo (2014). Association between body fat composition and blood pressure level among secondary school adolescents in Dar es Salaam, Tanzania. *Pan Afr Med J.; 19*: 327.
13. Joy E, De Souza MJ, Nattiv A, Misra M, Williams NI, Mallinson RJ.(2014 Jul-Aug). Female athlete triad coalition consensus statement on treatment and return to play of the female athlete triad. *Curr Sports Med Rep. 13*(4):219-32.

14. Brouha L, Graybiel A, Heath CW (1943). Step test: Simple method of measuring physical fitness for hard muscular work in adult man. *Rev Canad Biol.;2*:86-92.
15. http://www.who.int/bmi(WHO website)
16. https://c.ymcdn.com/sites/aparx.siteym.com/resource/resmgr/CEs/CE_Hypertension_The_Silent_K.pdf
17. Ghobadi H, Rajabi H, Farzad B, Bayati M, Jeffreys I (2013). Anthropometry of World-Class Elite Handball Players According to the Playing Position: Reports From Men's Handball World Championship 2013. *J Hum Kinet. 39*:213-20
18. GiordaniVasques, D, Da Silva Duarte, M. F. and Da Silva Lopes, A.(2007). Morfology of young handball players. *Rev. Bras. Cineantropometria Desempenho Hum., 9*(2):127-33.
19. Ramos-Campo, D. J.; Martínez-Sánchez, F.; Esteban-García, P.; Rubio-Arias, J. A.; Bores, C. A.; Clemente-Suarez, V. J. & Jiménez-Diaz, J. F. (2014). Body composition features in different playing position of professional team indoor players: basketball, handball and futsal. *Int. J. Morphol., 32*(4):1316-1324.
20. McArdle William D., Katch Frank I. , Katch Victor L (2010). Exercise Physiology: Nutrition, Energy, and Human Performance, Lippincott Williams & Wilkins; 844.
21. Jeukendrup Asker and Michael Gleeson (2010). Normal ranges of body weight and body fat. Sport Nutrition, Second Edition Human Kinetics..
22. Berdejo-del-Fresno Daniel, Amador J. Lara-Sanchez, José M. González-Rave (2012). Fitness Level and Body Composition of Elite Female Players in England Basketball League Division. *International Journal of Sport and Exercise Science, 4*(2): 15-24 15
23. Wilkinson Juliet (2015; Oct 16). Factors Effecting Systolic Blood Pressure. http://www.livestrong.com/article/67792-factors-effecting-systolic-blood-pressure.