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ANTHROPOMETRIC, MOTOR ABILITY AND PHYSIOLOGICAL PROFILES OF INDIAN NATIONAL CLUB FOOTBALLERS: A COMPARATIVE STUDY

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ABSTRACT

Football is probably the most popular game worldwide but there is still limited scientific information available concerning the physique and performance qualities of elite Indian footballers. Team games are sports where size, shape, body composition and fitness all play an important part in providing distinct advantages for specific playing positions. Hence an attempt has been made to study the various anthropometric parameters, motor ability and physiological profiles of the different Indian national club footballers and also to compare the above parameters with their international counterparts. The present study was carried out on one hundred fifty (150) male Indian footballers of six different national clubs of India including three from Kolkata (East Bengal, Mohan Bagan & Mohammedan Sporting) and other three from Goanese clubs (Salgaokar, Vasco & Dempo). The players were also sub-divided according to their specific field positions. Physical and physiological profiles including height, weight, percentage body fat (%BF), flexibility, agility, explosive power, and VO_2 max were measured by standard procedures. It was noted that the mean values of age, height, weight and %BF were significantly different among footballers of different national clubs. Among the motor ability and physiological qualities only flexibility, agility and VO_2 max were significantly different among the footballers of different national clubs ($p<0.01$). It was also observed that the mean values of height, weight, vertical jump and VO_2 max of Indian national club players were found to be inferior to those of European, American and Australian footballers. However, the %body fat of Indian footballers according to their specific field positions was found to be comparable with their international counterparts. The defender, midfielder and striker of the present study were inferior in endurance (VO_2 max) as compared to their international counterparts. Genetic factors may be the cause of smaller body size of the subject of the present study as compare to their international counterparts. So, it can be concluded that the differences among the footballers of present study with their international counterparts and specific playing position is probably the cause of hereditary factors and differences in activity in the game.

Key words: Indian national club footballers; Speed ability; Agility; Explosive power; VO_2 max; Footballers.

INTRODUCTION

Football is probably the most popular game worldwide but there is still limited scientific information available concerning the physique and performance qualities of elite Indian footballers. Not many sports physiologist have been attracted to examine the footballer in details because of the lack of adequate experimental models to study the games in the laboratory (Reilly *et al*, 1990). The game comprises activities like sprint and jumps in attack and defense. It also requires aerobic capacity as the game lasts one and half hour, sometimes even longer than the official time. These short and long lasting activities are performed over the entire game, so, both aerobic and anaerobic capacities are very important to exhibit better performance (Malcovic *et al.*, 1994).

Football is a team game. Team games are sports where body size, shape, body composition and level of fitness, all play an important part in providing distinct advantages for specific playing positions particularly at the highest levels of performance where there is a high degree of player specialization (Bale, 1986). Specific positional roles within each code may demand unique physiological attributes (Reilly *et al*., 1990). These are reflected in the physical and physiological fitness of the soccer players (Reeves *et al.*, 1999).

The database of physique and performance qualities of the players of the renowned clubs throughout the country is very important to make a National Team. It is a fact that in India there is still limited information of club footballers regarding physique, physiological profiles and performance except a study on Indian University Footballers (Kansal *et al.*, 1980a) in this regard. Hence an attempt has been made to study the physique and physiological qualities of the Indian national club footballers. The aims of the present study are i) to evaluate the various anthropometric and physiological profiles of Indian national club footballers and also to evaluate the above parameters according to their playing positions and, ii) to compare these parameters with Indian national players and also their international counterparts.

MATERIALS AND METHODS

Subjects

The present study was carried out on one hundred fifty (150) male Indian national league club footballers of mean age 23.3±3.50 years. All the footballers were chosen from the six different national league clubs of India including three from Kolkata (East Bengal, Mohan Bagan & Mohammedan Sporting) and three from Goanese clubs (Salgaokar, Vasco & Dempo). The players of East Bengal, Mohan Bagan and Mohammedan Sporting were tested at Sports Authority of India (SAI), Eastern Center, Kolkata and the players of three Goanese clubs were investigated at Nehru Stadium, Margaon, Goa. The players consisted of 23 goalkeepers, 44 defenders, 48 midfielders and 35 strikers. Another 43 Indian national footballers were also investigated for their various physical and physiological profiles (parameters were tested as tested on national league club footballers) at Sports Authority of India (SAI), Eastern Center, Kolkata. Before the tests all the players were clinically examined by Doctors, specialized in Sports Medicine of Sports Authority of India. Prior to initial testing a complete explanation of the purposes, procedures and potential risks and benefits of the tests were explained to all footballers and consent was obtained from all the players. The

player who was found clinically fit, healthy and no history of any heart and lung diseases was finally selected for the following tests.

The various anthropometric parameters of the players including height (cm) and weight (kg) were recorded by following the standard procedures (Sodhi, 1991). The decimal age of the footballers were calculated from their date of birth recorded at the time of testing. Skinfold thickness was recorded by Harpenden Skinfold caliper at the site of biceps, triceps, subscapular and suprailliac (Eston *et al*., 1995). Body density was calculated using the equation of Siri (1961) and %Body Fat (%BF) was calculated by the formula of Durnin & Womersley (1974**)**. Body Mass Index (BMI) was calculated from body height and weight (WHO, 1995).

The hip and back flexion as well as extension of the hamstring muscles of the leg was evaluated by modified Sit-and-Reach Test (Johnson & Nelson, 1988). Explosive power of lower limbs i.e., the power of the legs in jumping vertically upwards was measured by using the standard method of Verduci (Verduci, 1980). The speed ability of the subjects was assessed by 20-meter sprint by adopting the standard procedure (Rösch *et al*, 2000). Agility of the body (measurement of coordination and speed) maneuvering in forward, backward and sideward directions was evaluated by the Semo Agility test, which was adopted by Kirby (1971).

Maximum aerobic power (VO_2 max) was assessed to use an indirect method of multistage fitness test (Beep test) (Leger *et al*., 1988) from where VO_2 max was predicted. It is a progressive shuttle run test for the prediction of aerobic fitness as well as to estimate a person's maximum oxygen uptake capacity (VO_2 max) from the standard chart. The procedures and purpose of the above test were elaborately instructed to all the players. Briefly, players ran back and forth between two lines, spaced 20-m apart, in time with the "beep" sounds from a compact disc (20-m Shuttle Run test CD). Each successful run of the 20-m distance was a completion of a shuttle. The "beep" sounded at a progressively increasing pace with every minute of the test and correspondingly the player must increase his running speed accordingly. The player was warned if he did not reach the end line in time once. The test was terminated when he i) could not follow the set pace of the "beeps" for two successfully shuttles and/or ii) stopped voluntarily. Typically the scores in the test are expressed as levels and shuttles, which estimate a person's maximum oxygen uptake capacity (VO_2 max) from the standard chart. The laboratory tests were performed at a room temperature varying from 23°C to 25°C with the relative humidity varying between 50 and 60%. The field test was performed at temperature about 30°C with relative humidity of maximum about 70-80%.

Statistical analysis

Software, SPSS (Ver. 9.0) was used to analyze the collected data. Mean, standard deviation and one-way ANOVA were performed to see whether any significant differences among footballers and also according to their playing positions. After completion of the one-way ANOVA, Scheffe's *F* test was also used for multiple comparisons between clubs.

RESULTS

The various anthropometric, motor ability and physiological parameters of Indian National League club footballers were presented in table 1 and table 2a respectively. The mean age, height, weight, BMI and %BF were significantly different among footballers of different national clubs (table 1). Regarding motor qualities, flexibility, agility and VO_2 max were also found to be significantly different among the footballers of different clubs ($P<0.01$). No such significant difference was observed in case of Standing Vertical Jump (SVJ) and 20 m sprint.

TABLE 1. **COMPARISON OF PHYSICAL CHARACTERISTICS AND BODY FAT% OF INDIAN NATIONAL LEAGUE CLUB FOOTBALLERS**

Variables	East Bengal (n=23)	Mohan Bagan (n=23)	Mohammedan Sporting (n=31)	Salgaokar (n=25)	Vasco (n=23)	Dempo (n=25)	F value with level of significance
Age (yrs)	24.6 ±3. 61	22.5 ±2.76	22.7 ±3.02	21.6 ±3.42	23.3 ±3.51	24.7 ±3.90	3.18**
Height (cm)	171.9 ±5.60	170.9 ±5.47	170.5 ±5.07	174.2 ±5.12	172.8 ±5.21	169.0 ±5.53	2.65*
Weight (kg)	67.3 ±5.48	66.4 ±5.40	64.5 ±5.53	63.9 ±5.46	63.4 ±5.47	61.0 ±5.75	2.64*
BMI	22.8 ±1.82	22.5 ±1.46	21.9 ±1.54	20.9 ±1.43	21.2 ±1.81	21.2 ±1.80	4.82**
% Body fat	13.5 ±2.75	12.2 ±2.76	11.6 ±2.28	14.3 ±1.27	14.2 ±2.02	15.1 ±1.93	9.62**

Values are (mean ± sd); **, $P<0.01$; *, $P<0.05$

TABLE 2a. **COMPARISON OF SELECTED MOTOR ABILITY PARAMETERS AND PHYSIOLOGICAL PROFILES OF INDIAN NATIONAL LEAGUE CLUB FOOTBALLERS**

Variables	East Bengal	Mohan Bagan	Mohammedan Sporting	Salgaokar	Vasco	Dempo	*F* value with level of significance
Flexibility (cm)	35.4 ±6.88	38.9 ±4.05	35.3 ±5.62	37.8 ±4.98	36.1 ±7.26	36.3 ±7.77	3.94**
Standing vertical jump (cm)	44.1 ±4.34	42.6 ±4.91	43.8 ±4.74	42.2 ±4.63	43.1 ±4.73	45.6 ±4.72	1.11ns
Speed ability-20m sprint (sec)	3.0 ±0.12	3.0 ±0.10	2.9 ±0.15	3.0 ±0.11	2.9 ±0.12	3.1 ±0.16	0.90ns
Semo agility (sec)	12.2 ±0.61	11.9 ±0.51	12.3 ±0.55	11.6 ±0.34	11.6 ±0.43	12.2 ±0.67	9.49**
VO_2 max ($ml.kg^{-1}.min^{-1}$)	52.3 ±4.27	52.6 ±4.90	51.4 ±4.04	55.2 ±4.18	55.0 ±4.10	54.4 ±3.89	3.36**

Values are (mean ± sd); **, $P<0.01$; ns, not significant

TABLE 2b. **SCHEFFE'S *F* TEST FOR MULTIPLE COMPARISONS OF SELECTED ANTHROPOMETRIC, MOTOR ABILITY AND PHYSIOLOGICAL PARAMETERS OF INDIAN NATIONAL LEAGUE CLUB FOOTBALLERS**

Variables	EB *VS* MB	EB *VS* MS	EB *VS* SAL	EB *VS* VAS	EB *VS* DEM	MB *VS* MS	MB *VS* SAL	MB *VS* VAS	MB *VS* DEM	MS *VS* SAL	MS *VS* VAS	MS *VS* DEM	SAL *VS* VAS	SAL *VS* DEM	VAS *VS* DEM
Height	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	*
Weight	ns	ns	ns	ns	*	ns	ns	ns	*	ns	ns	ns	ns	ns	ns
BMI	ns	ns	*	ns	ns	ns	*	ns	ns	ns	ns	ns	ns	ns	ns
%Body fat	ns	*	ns	ns	ns	ns	*	ns	*	*	*	*	ns	ns	ns
Flexibility	*	ns	ns	ns	ns	*	ns	*	*	*	*	ns	ns	ns	ns
Agility	ns	ns	*	*	ns	ns	ns	ns	ns	*	*	ns	ns	*	*
VO_2 max	ns	ns	*	*	ns	ns	ns	*	ns	*	*	*	ns	ns	ns

EB, East Bengal; MB, Mohan Bagan; MS, Mohammedan Sporting; SAL, Salgaokar; VAS, Vasco; DEM, Dempo *, $P<0.05$; ns, not significant; Scheffe's *F* values for significance at 0.05 level is 11.45

Table 2b represents Scheffe's *F* test for multiple comparisons of selected anthropometric, motor ability and physiological parameters of national league club footballers. The table depicted that the height was only found to be statistically significant when Dempo was compared with Salgaokar and Vasco respectively. On the other hand, body weight was significantly different when Dempo was compared with East Bangal and Mohan Bagan players. Like height and weight BMI also found to be significantly different when Salgaokar was compared with East Bengal and Mohan Bagan respectively. Percentage body fat was also significantly different between East Bengal vs Mohammedan Sporting, Mohan Bagan vs Salgaokar, Mohan Bagan vs Dempo, Mohammedan Sporting vs Salgaokar, Mohammedan Sporting vs Vasco and Mohammedan Sporting vs Dempo respectively. Almost similar observations were made in case of flexibility when Mohan Bagan compared with East Bangal and Mohammedan Sporting and significant differences were also observed in this regard. The VO_2 max and agility was found to be significantly different when East Bengal and Mohammedan Sporting compared with Salgaokar and Vasco respectively.

TABLE 3a. **COMPARISONS OF PHYSICAL CHARACTERISTICS, SELECTED MOTOR ABILITY PARAMETERS AND PHYSIOLOGICAL PROFILES OF INDIAN NATIONAL LEAGUE CLUB FOOTBALLERS (COMBINED, N=150) ACCORDING TO SPECIFIC FIELD POSITIONS**

Variables	Goalkeeper (n=23)	Defender (n=44)	Midfielder (n=48)	Striker (n=35)	*F* value with level of significance
Age (yrs)	23.3 ± 3.95	23.1 ± 3.26	23.3 ± 3.62	23.2 ± 3.46	0.03^{ns}
Height (cm)	173.8± 5.33	170.8 ± 5.78	171.9 ± 5.98	170.9 ± 5.76	1.52^{ns}
Weight (wt)	66.7 ± 5.56	63.2 ± 8.07	64.9 ± 6.52	63.5 ± 6.38	1.55^{ns}
% Body fat	14.0 ± 2.61	13.8 ± 2.05	13.3 ± 2.41	13.6 ± 2.15	0.76^{ns}
BMI	22.1 ± 1.66	21.6± 2.06	22.0 ± 1.62	21.7 ± 1.75	0.49^{ns}
Flexibility (cm)	43.8± 7.79	40.6± 6.18	36.1± 4.94	39.7± 5.84	8.45**
Standing Vertical Jump (cm)	43.7 ± 5.42	44.4 ± 5.93	43.3 ± 4.94	43.7 ± 5.31	0.34^{ns}
20m sprint (sec)	2.96 ± 0.13	2.97 ± 0.13	2.96 ± 0.13	2.99 ± 0.17	0.48^{ns}
Semo agility (sec)	12.0 ± 0.61	12.1 ± 0.63	11.8 ± 0.51	12.0 ± 0.67	1.62^{ns}
VO_2 max ($ml.kg^{-1}.min^{-1}$)	53.1± 3.60	53.7± 4.72	55.2± 5.02	53.8± 4.43	3.14*

Values are (mean ± sd); overall difference is made in one-way ANOVA, s^{*}, $P<0.05$; ^{ns}, not significant

The various anthropometric, motor ability and physiological parameters according to their specific field positions of Indian National League club footballers were presented in table 3a. It is evident from the table that goalkeepers were the tallest and heaviest among the players of different playing positions although the differences were found to be statistically insignificant. Percentage body fat was also found to be higher in goalkeeper as compared to their other counterparts and the value was found to be statistically insignificant like height and weight. Trunk flexibility and VO_2 max were found to be significantly different among the players of different playing positions. However, the mean flexibility was found to be higher in goalkeeper and VO_2 max was found to be higher in midfielders respectively as compared to the players of other field positions. Scheffe's-*F* test for multiple comparisons among the Indian national club footballers according to their specific field positions were presented in table 3b. It is evident from the table that the flexibility of goalkeepers and defenders were found to be significantly different when compared with midfielders. On the other hand VO_2 max was found to be significantly different between midfielder and striker. No such significant differences were observed among the players of other field positions.

TABLE 3b. **SCHEFFE'S *F* TEST FOR MULTIPLE COMPARISONS OF SELECTED MORPHOLOGICAL, MOTOR ABILITY PARAMETERS AND PHYSIOLOGICAL PROFILES**

Variables	GK *VS* DEF	GK *VS MF*	GK *VS* ST	DEF *VS* MF	DEF *VS* ST	MF *VS* ST
Flexibility	ns	*	ns	*	ns	ns
VO_2 max	ns	ns	ns	ns	ns	*

GK, Goalkeeper; DEF, Defender; MF, Midfielder; ST, Striker *, P<0.05; ns, not significant; Scheffe's *F* values for significance at 0.05 level is 8.04

TABLE 4. **COMPARISON OF PHYSICAL CHARACTERISTICS AND PHYSIOLOGICAL PROFILES OF THE INDIAN NATIONAL CLUB FOOTBALLERS WITH THEIR INTERNATIONAL COUNTERPARTS**

Teams & Authors	Age (yrs)	Height (cm)	Weight (kg)	%Body fat	Vertical Jump (cm)	VO_2 max ($ml.kg^{-1}min^{-1}$)
English League, First Division (White *et al.,* 1988), n=17	23.3	180.4	76.7	19.3	59.8	49.6
Aberdeen F.C. (Williams *et al.,* 1973), n=9	--	174.6	69.4	14.9	--	--
Dallas Tornado (Raven *et al.,* 1976), n=18	26.0	176.0	75.5	9.6	--	58.4
Italian Professionals (Faina *et al.,* 1988), n=27	26.0	177.2	74.4	--	--	63.2
Ujpesti Dozja, Budapest (Apor, 1988)	22.9	176.5	70.5	--	52.5	66.6
American National Team (Wilmore & Haskel, 1972; Douge, 1988), n=44	22.2	178.0	77.0	14.4	56.0	59.2
Indian National Team (2003), n=43	23.2	173.5	66.9	13.9	45.2	54.2
Present study of Indian national club footballers, n=150	23.3	171.6	64.4	13.6	43.7	53.6

Table 4 represents the comparison of various anthropometric, motor ability and physiological parameters of the Indian national club footballers with the players of Indian national team and their international counterparts. The mean values of height, weight, %BF, vertical jump and VO_2 max of the Indian national team (2003) and Indian national club footballers (present study) were found to be well comparable. But the above parameters were found to be higher in their International Counterparts except English First Division League footballers who were found to be less in VO_2 max than the present study.

TABLE 5. **COMPARISON OF CERTAIN PHYSICAL AND PHYSIOLOGICAL PARAMETERS OF INDIAN NATIONAL LEAGUE FOOTBALLERS WITH THEIR INTERNATIONAL COUNTERPARTS ACCORDING TO THEIR SPECIFIC PLAYING POSITIONS**

Teams & Authors	Position	Age (yrs)	Height (cm)	Weight (kg)	%Body fat	VO_2 max ($ml.kg^{-1}min^{-1}$)
Association football players college level (Bell & Rhodes, 1975)	Goalkeeper (n,7)	20.8	180.3	80.8	16.9	-
	Defender (n,20)	20.8	176.8	72.5	14.7	
	Midfielder (n,18)	20.8	173.4	68.1	14.6	
	Striker (n,16)	20.8	177.2	69.2	14.7	
South Australian Republic (Withers *et al*., 1977)	Defender (n,1)	-	188.6	83.5	14.0	61.6
	Midfielder (n, 3)		175.1	72.6	17.0	61.7
	Striker (n,1)		176.6	74.8	13.6	63.4
Indian national (Kansal *et al.,* 1980a)	Defenders (n,22)	-	173.1	59.4	10.2	-
	Midfielders & Strikers (n,24)	-	165.3	52.4	9.4	-
Indian University Champions (Kansal *et al.,* 1980b)	Goalkeeper (n, 6)	-	-	60.3	14.3	39.7
	Defender (n,6)			59.8	13.2	42.9
	Midfielder (n, 5)			58.2	12.4	43.2
	Striker (n, 12)			55.0	10.4	47.6
Indian national footballers (2003)	Goal Keeper (n,5)	23.2	178.9	69.7	12.3	51.9
	Defender (n,12)	23.8	174.2	66.1	12.0	54.3
	Midfielder (n,17)	23.2	173.2	66.9	12.8	55.2
	Striker (n,9)	22.6	170.8	66.3	12.7	53.1
Present study of Indian national club footballers	Goal Keeper (n,23)	23.3	173.8	66.7	14.0	53.1
	Defender (n,44)	23.1	170.8	63.2	13.8	53.7
	Midfielder (n,48)	23.3	171.9	64.9	13.3	55.2
	Striker (n,35)	23.2	170.9	63.5	13.6	53.8

A comparison of physical and physiological parameters of the Indian national club footballers were also been made with their international counterparts according to their specific playing positions (table 5). However, mean values of height, weight, vertical jump and VO_2 max were found to be higher in European, American and Australian footballers as compare to Indian footballers. The mean values of height, weight and %BF of goalkeeper, defender, midfielder and striker of Indian national club footballers (present study) were well comparable with Indian University Players (Kansal *et al*., 1980a and Kansal *et al*., 1980b), but body height and weight are lower than Indian national team. However, %BF of Indian footballers (according to their specific field positions) is well comparable with their international counterparts (table 5). But defender, midfielder and striker of the present study were found to be inferior in VO_2 max than their international counterparts but well comparable with Indian national players.

DISCUSSION

The present study reveals that the mean values of height and weight were less than their International counterparts (table 4). Generally Asians are smaller in size than Non-Asians (Ekblom, 1994). The small sizes of Indians are probably due to genetic cause. It is well established that ethnic and racial factors which affects the average body size (Hirata, 1966). However, morphological factors are not a bar to success in soccer though it might determine a positional role most appropriate for the players (Ekblom, 1994).

It was also found that there were differences in the anthropometric characteristics and body composition associated with playing positions. This was supported by Reeves *et al.* (1999) who found that there were differences in the anthropometric characteristics and body composition associated with playing position. In the past a study of English Players at College Level confirmed that goalkeepers (mean 180 cm) were the tallest than other team members (Bell & Rhodes, 1980). This trend was supported by observations of Professional English League Players, the centre-backs being taller than the full backs with midfield players being the smallest of those playing outfield Reilly (1979). So, height does bestow an advantage to the goalkeeper, the centre-backs and to the forward used as the "target man" for winning the possession of the ball with his head (Reilly *et al*., 1990). Thus a particular stature may orient players towards specific positional or tactical roles. A particular body size may encourage the acquisition of certain skills and force of gravitation towards a specific playing position.

Body composition is an important aspect of fitness for soccer players. An excess body fat acts as dead mass in activities when body mass is lifted repeatedly against gravity in running and jumping during play (Ekblom, 1994). Percentage body fat of the present subjects was found to be lower than Indian sedentary male population of same age (Uppal, 1992). The mean values of %BF of Indian national club footballers and Indian national footballers were less than European and Australian footballers although it is comparable with American footballers. In fact, authors could not explain the probable cause of this result due to lack of information about socioeconomic life style, food habit and methods of %BF measurement of European, American and Australian footballers. So, these are the very important factors while making any conclusions about %BF variations of an individual. However, goalkeeper posses more fat (14.0± 2.61) than the players of other field positions although the differences were found to be statistically insignificant. De Rose (1975) also recorded higher %BF in goalkeeper than in outfield players and concluded that the difference was probably because of the lighter metabolic loading improved by match play and training of goalkeeper. Such difference may also be due to less activity of the goalkeeper in the game. However, habitual physical activity, diet and stage of competitive seasons were not systematically considered when the %Body fat was evaluated in the present subjects, as those are also important factors in this context.

The flexibility is another important factor in soccer. Strength imbalance between the limbs increases the occurrence of injury. The average range of trunk flexibility of Indian national club footballers varies between 36.1- 43.8 cm. However, mean value of flexibility was noted higher in goalkeeper than the player of other field positions. Due to less number of literatures, investigators could not compare flexibility of Indian players with their International

counterparts. However, Douge (1988) has reported that the American footballers tend to have greater flexibility as compared to their International counterparts.

Standing vertical jump is commonly used to measure the explosive power of lower limbs. The mean vertical jump of Indian national players and Indian national club footballers were found to be much lower than English, Australian and American footballers (table 4). The probable reason of the lower value in vertical jump of Indian footballers may be due to smaller body structure than English, Australian and American footballers (Ekblom, 1994). However, the higher vertical jump was found among defender as compared to their counterparts of other field positions. Reilly (1979) has also reported that defender had relatively high mean scores in vertical jump than midfielder. The result of the present study was also corroborated with the study of above authors.

Speed ability is the performance pre-requisite to perform motor actions under given conditions (movement task, external factor, individual pre-requisites) in minimum of time (Thiess & Schnabel, 1987). Like other qualities the speed ability also plays an important role in soccer. An accelerated pace of the game calls for rapid execution of typical movements by every member in a team. In many instances, successful implementation of certain technical or tactical maneuvers by different team members is tied up with the degree of velocity deployed. In this connection the experimental analysis of the sprint capacity of football players such as split times and mean velocities of the total running distance are indicative of individual strong and weak points in sprinting performance (Kollath & Quade, 1990). The mean values of speed ability of Indian national team and Indian national club footballers were found to be 2.95 and 3.2 seconds respectively. Due to lack of literature, the investigators also could not compare speed ability of Indian players with their other counter parts.

Agility is the physical ability, which enables an individual to rapidly change the body position and direction in precise manner (Johnson & Nelson, 1988). It is not a single ability but a complex of several abilities (Mattausch, 1973; Meinel & Schnabel, 1976; Blume, 1978). These abilities are primarily dependent upon the coordinative processes of the central nervous system, which are important in sports. The average value of agility of Indian national team and Indian national club footballers were found to be 12.0 second. However, the midfielders were more agile as compare to the players of other positions and which may be due to their nature of activity in the game. Agility also could not be compared with their international counterparts as in the case of flexibility.

The upper limit of the body's ability to consume oxygen is indicated by the maximal oxygen consumption (VO_2 max). This is the maximum rate at which energy can be released from the oxidative process exclusively (Bouchard *et al*., 1994). For this reasons it is an essential measurement in the study of footballers. Aerobic power of present study was found to be higher than those of the average Indian male population (Chatterjee & Chakroborty, 1986). Maximum oxygen uptake capacity(VO_2 max) is the highest rate at which an individual can consume oxygen during exercise, limits the capacity to perform aerobic exercise and therefore, serves as the most popular index of aerobic fitness (Armstrong & Weisman, 1994). The average values of VO_2 max for top-level soccer players tend to be higher (Ekblom, 1994). On the other hand, the mean values of VO_2 max of Indian national club footballers and Indian national footballers were comparatively less than European and Australian footballers

and well comparable with Croatian footballers. However, the maximal oxygen consumption of the present study was found to be higher in midfielders and significantly different among the players of different playing positions. Maximum oxygen uptake capacity does vary with specific field position, when such positional roles can be clearly differentiated. However, it was evident that when English League players were subdivided as per playing positions, the midfield players had significantly higher aerobic power than those of other positions. The defenders had lower value while the strikers had intermediate value (Reilly, 1975). Indeed the significant correlation between VO_2 max and distance covered in a game (r=0.67) demonstrates the need for a high work-rate in midfield players as they act as a link between defense and attack. The goalkeeper was found to have lower values even than the defenders. Four goalkeepers in the German National squad had average values of 56.2 (± 1.2) ml kg^{-1} min^{-1} as compared to 62.0 (±4.5) ml kg^{-1} min^{-1} for the squad as a whole (Hollmann *et al*., 1981). A study of 95 young non-professional soccer players found that goalkeeper had significantly lower VO_2 max values than the outfield players (Caru *et al*., 1970). The present study was also corroborated with the study of above authors that midfielder showed higher value and lowest value in goalkeeper.

It is clear from the above discussions not only the anthropometric measures but also the various motor abilities and physiological parameters were less in case of Indian national club footballers and as well as Indian national players. Genetic factors determine body size and also to some extent physiological qualities. Body size does bestow and advantage to the goalkeeper, center back and the forward. Usually strength, stamina, power and skills are important factors for success in football. However, the motor abilities and aerobic power are found to be poor in Indian footballers as compare their International counterparts. Although in this study the specific football skills are not performed but on the basis of specific motor qualities and maximum aerobic power it can be said that Indian footballers are lagging behind as compare to European, American and Australian footballers not only in success in wining the medal but also physical fitness.

So, it may be concluded that the less physical and physiological qualities of Indian soccer players as compare to their International counterparts may be due to genetic influence and also the difference among the players of various playing positions may be due to their activity in the game and difference in training regimen.

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REFERENCES

APOR, P. (1988). Successful formulae for fitness training. In T. Reilly; A. Lees; K. Davids & W.J. Murphy (Eds.), *Science and Football* (95-107). London: E & FN Spon.

ARMSTRONG, N. & WEISMAN, J.R. (1994). Assessment and interpretation of aerobic fitness in children and adolescents. In J.E. Holloszy (Ed.), *Exercise and Sport Science Review* (435-476). Philadelphia, PA: Williams & Wilkins Publications.

BALE, P. (1986). A review of the physique and performance qualities, characteristics of game players in specific positions on the field of play. *Journal of Sports Medicine and Physical Fitness,* 20: 109-121.

BELL, W. & RHODES, G. (1975). The morphological characteristics of the association football player. *Journal of Sports Medicine & Physical Fitness*, 20: 196-200.

BLUME, D.D. (1978). Zu einigen wesentlichen theoretischen Grundlagen für die Untersuchung der koordinativen Fahigkeiten. *Theorie und Praxis der Korperkultur*, 1: 29-36.

BOUCHARD, C.; SHEPHARD, R.J. & STEPHENS, T. (1994). *Physical activity, fitness, and health*. Champaign, IL: Human Kinetics.

CARU, B.; LECOULTRE, L.; AGHEMO, P. & PINERA, L.F. (1970). Maximal aerobic and anaerobic muscular power in football players. *Journal of Sports Medicine & Physical Fitness*, 10: 100-103.

CHATTERJEE, S. & CHAKROBORTY, B. (1986). Comparative study of maximal aerobic capacity by three ergometrics in untrained college women. *Japanese Journal of Physiology*, 36: 151-162.

DE ROSE, E.H. (1975). Determination of the ideal body weight and corporal composition of 16 professional soccer players. *Questions of athletes nutrition*: Abstract of the reports of the international symposium. Leningrad: Leningrad Institute of Physical Culture.

DOUGE, B. (1988). Football: the common threads between the games. In T. Reilly; A. Lees; K. Davids & W.J. Murphy (Eds.), *Science and Football* (3-19). London: E & FN Spon.

DURNIN, J.V.G.A. & WOMERSLEY, J. (1974). Body fat assessed from the total body density and its estimation from skinfold thickness measurements on 481 men and women aged 16-72 years. *British Journal of Nutrition*, 32: 77-97.

EKBLOM, B. (1994). Physiological profiles of the players. In B. Ekblom (Ed.), *Football soccer* (78-93). London: Blackwell Scientific Publications.

ESTON, R.G.; FU, F. & FUNG, L. (1995). Validity of conventional anthropometric techniques for predicting body composition in healthy Chinese adults. *British Journal of Sports Medicine*, 29(1): 52-56.

FAINA, M.; GALLOZZI, C.; LUPO, S.; COLI, R.; SASSI, R. & MARINI, C. (1988). Definition of the physiological profile of the soccer player. In T. Reilly; A. Lees; K. Davids & W.J. Murphy (Eds.), *Science and Football* (158-163). London: E & FN Spon.

HIRATA, K. (1966). Physique and age of Tokyo Olympic champions. *Journal of Sports Medicine & Physical Fitness*, 6: 207-222.

HOLLMANN, W.; LIESEN, H. & MADER, A. (1981). Zur Hochstund Dauerleistungsfahigkeit der Deutschen Fussball-Spitzenspieler (High endurance performance of German elite football players). *Deutsche Zeitschrift für Sportsmedizine*, 32: 113-120.

JOHNSON, B.L. & NELSON, J.K. (1988). *In practical measurements for evaluation in physical education* (3rd ed.) (2nd Indian reprint). New Delhi, India: Surjeet Publications.

KANSAL, D.K.; VERMA, S.K. & SIDHU, L.S. (1980a). Anthropometric characteristics of Indian university football players. *Journal of Sports Medicine & Physical Fitness*, 20(3): 275-284.

KANSAL, D.K.; VERMA, S.K. & SIDHU, L.S. (1980b). Introspective differences in maximum oxygen uptake and body composition of Indian players in hockey and football. *Journal of Sports Medicine & Physical Fitness*, 20(3): 309-316.

KIRBY, R.F. (1971). A simple test of agility. *Coach and athlete*, 25(6): 30-31.

KOLLATH, E. & QUADE, K. (1990). Measurement of sprinting speed of professional and amateur soccer players. In T. Reilly; J. Clayers & A. Stibbe (Eds.), *Science in football II* (31-36) (1st ed.). London: E & FN Spon.

LEGER, L.A.; MERCIER, D.; GADOURY, C. & LAMBERL, J. (1988). The multistage 20-meter shuttle run test for aerobic fitness. *Journal of Sports Science,* 6: 93-101.

MALKOVIC, B.R.; JANKOVIC, S. & HEIMER, S. (1994). Physiological profiles of top Croatian soccer players. In T. Reilly; J. Clayers & A. Stibbe (Eds.), *Science in football II* (37) (1st ed.). London: E & FN Spon.

MATTAUSCH, W.D. (1973). Zu einigen Problemen der begrifflichen Fixierung der konditionellen und koordinativen Fahigkeiten. *Theorie und Praxis der Körperkultur*, 22 (9): 849-856.

MEINEL, K. & SCHNABEL, G. (1976). *Bewegungelehre.* Berlin: Volk und Wissen Volkseigner Publications.

RAVEN, P.; GETTMAN, L.; POLLOCK, M. & COPPER, K. (1976). A physiological evaluation of professional soccer players. *British Journal of Sports Medicine*, 109: 209-216.

REEVES, S.L.; POH, B.K.; BROWN, M.; TIZZARD, N.H. & ISMAIL, M.N. (1999). Anthropometric measurements and body composition of English and Malaysian footballers. *Malaysian Journal of Nutrition*, 5: 79-86.

REID, R.M. & WILLIAMS, C. (1974). A concept of fitness and its measurement in relation to rugby football. *British Journal of Sports Medicine*, 8: 96-99.

REILLY, T. (1975). An ergonomic evaluation of occupational stress in professional football. Unpublished PhD dissertation. Liverpool: Liverpool Polytechnic.

REILLY, T. & THOMAS, V. (1976). A motion analysis of work-rate in different positional roles in professional football match play. *Journal of Human Movement Studies*, 2: 87-97.

REILLY, T. (1979). *What research tells the coach about soccer*. Washington, DC: AAHPERD.

REILLY, T.; SECHEI, N.; SNELL, P. & WILLIAMS, C. (1990). *Physiology of sports*. London: E & FN Spon.

REILLY, T. (1996). *Science and soccer*. London: E & FN Spon.

RÖSCH D.; HODGSON, R.; PETERSON, L.; GRAF-BAUMANN, T.; JUNGE, A.; CHOMIAK, J. & DVORAK, J. (2000). Assessment and evaluation of football performance. *American Journal of Sports Medicine*, 28: 29-39.

SIRI, W.E. (1961). Body composition from fluid spaces and density: analysis of methods. In J.A. Brojak (Ed.). *Technique for measuring body composition* (223-244). Washington, DC: National Academy of Science Nation Research Council.

SODHI, H.S. (1991). *Sports anthropometry (a kinanthropometric approach)*. Mohali, Chandigarh, India: ANOVA Publications.

THIESS, G. & SCHNABEL, G. (1987). *Leistungsfaktoren in Training und Wettkampf*. Berlin: Sportsverlag.

UPPAL, A.K. (1992). *Physical fitness - how to develop*. Delhi: Friends Publications.

VERDUCI, F.M. (1980). Measuring the health related physical fitness domain. In C.V. St Lowis (Ed.). *Measurement concept in Physical Education* (247-287.). St. Louis, IL: Mosby.

WHITE, J.E.; EMERY, T.M.; KANE, J.L.; GROVES, R. & RISHMAN, A.B. (1988). Pre-season fitness profiles of professional soccer players. In T. Reilly; A. Lecs; K. Davids & W.J. Murphy (Eds.). *Science and Football* (164-171). London: E & F.N. Spon.

WILLIAMS, G.; REID, R.M. & COUTTS, R. (1973). Observations on the aerobic power of university rugby players and professional soccer players. *Brittish Journal of Sports Medicine*, 7: 390.

WILMORE, J.H. & HASKEL, W.L. (1972). Body composition and endurance capacity of professional football players. *Journal of Applied Physiology*, 33: 564-567.

WITHERS, R.T.; ROBERTS, R.G.D. & DAVIS, G.J. (1977). The maximal aerobic power, anaerobic power and body compositions of South Australian male representatives in athletics, basketball, field hockey and soccer. *Journal of Sports Medicine & Physical Fitness*, 17(4): 391-400.

WORLD HEALTH ORGANIZATION (WHO) (1995). *The use and interpretation of anthropometry*. Geneva, Switzerland: WHO Technical Report Series Publications.

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