

PHYSICAL AND PHYSIOLOGICAL CHARACTERISTICS OF ELITE INDIAN NATIONAL FOOTBALL PLAYERS

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ABSTRACT:

Background: No profiling studies have been done on the Elite Indian Football players. The purpose of the study was to study the physical and physiological characteristics of Elite Indian Football Players.

Methods: In order to explore the physical and physiological characteristics of elite Indian football players and compare these results according to playing positions 28 current and past Indian under/22 years national players (height 1.73 ± 0.03 m; body mass 71.8 ± 2.5 kg; age 25.1 ± 1.1 years) underwent a series of anthropometric, physical and physiological assessments including skinfold assessment, isokinetic knee extensors and flexors strength, vertical jump, maximal ball kick velocity, Yo-Yo Intermittent Recovery Test, Illinois agility test, and sprint performance.

Results: Positional differences influenced results. Body fat was lowest ($16.0 \pm 0.7\%$) for forwards ($p < 0.01$) who were also most agile. Midfielders were strongest ($p < 0.01$) and the most aerobically fit players ($p < 0.05$). Significant correlations between isometric strength and jumping performance ($r = 0.37$) and kicking velocity ($r = 0.43$) were found. Body fat was well correlated to agility ($r = 0.70$), dynamic knee flexion ($r = 0.78$) and extension ($r = 0.76$) strength, and maximal ball kick velocity ($r = 0.42$).

Conclusion: Position specific characteristics appear to exist and need to be considered for training purposes. However, results suggest that currently Indian players are not meeting physical and physiological standards expected for professional international footballers.

Keywords: Soccer, Endurance, Aerobic Capacity, Muscular Power

INTRODUCTION

Football is the most popular sport globally [1, 2]. and there is a growing interest for this sport in India. However the Indian national team is currently ranked 166 of 207 according to the Federation International de Football Association (FIFA). The ranking suggests that Indian playing standards need to be improved in line with three key areas previously reported to be related to successful football performance, namely physical, technical, and tactical skills [3].

Physiological characteristics that have been reported as essential for football players are aerobic fitness, agility, muscle strength, speed, and explosive jumping power [4]. While aerobic fitness contributes up to 90% of energy utilization during football matches [5], typically high intensity bouts of sprinting are necessary to score goals [6]. These efforts may be complemented by jumping used by footballers when controlling the ball in the air and to score or defend goals by way of heading. Sprinting accounts for approximately only five percent of the match

Duration [7] with each sprint covering up to 30 meters [8] and most efforts not completed in a straight line. Thus, acceleration, speed, and agility are determined by the athletes muscle strength and power [9], and can be effectively trained through a well-developed and structured program [10]. These key components have been shown to differentiate elite and non-elite players independent of football specific skills such as ball control, dribbling, and tackling [11]. However, it remains unknown how elite Indian footballers compare with previously reported physiological results of professional footballers. Determining these outcomes may likely provide the foundation for targeted training programs which over time would increase the playing standard of Indian football. Previous literature has demonstrated that each specialized playing position may have unique physical and physiological requirements [7,12,13]. Therefore, understanding the profile of successful players is valuable for talent identification, ensuring players are assigned to their optimal positions, and provide assistance in the design of conditioning programs [14].

Despite much research in Europe and United States [11] to our knowledge very little information is available about the characteristics of elite football in South Asia, particularly India. To date, there appears to be only one published report of physiological characteristics of Indian football players [15]. They reported maximal aerobic capacity of the players exceeded controls by 28% (i.e. 60 vs 43 ml.kg⁻¹.min⁻¹), which was similar to other international footballers. However, the results were determined from a single submaximal test only and reported for the entire group. Therefore, the aim of this study was to determine the anthropometric, physical and physiological characteristics of elite Indian footballers and examine if there were differences according to their playing position. A secondary aim was to investigate the relationships amongst lower limb isokinetic strength, sprinting speed, aerobic capacity, agility, and vertical jump height. These outcomes will increase the understanding of the level of Indian football, which can be used to develop more effective training programs for these athletes.

Materials & Methods

Overview and Participants

Twenty-eight football players, comprising past and current under 22 (u/22) national squad members from a number of local elite national teams, underwent a series of anthropometric, physical and physiological testing during May and June 2012 corresponding to the I-League pre-season period. The study was approved by the Ethics Committee of the Faculty of Sports Medicine and Physiotherapy, Guru Nanak Dev University, Amritsar. All players were informed of the nature of the study and provided written consent prior to the participation.

Players completed testing over three days. The first day anthropometric measurements were collected followed by isokinetic strength and vertical jump performance. Day two was dedicated to aerobic testing, which was measured using the Yo-Yo Intermittent Recovery Test (YYIRT). Agility, sprinting, and maximal kicking power were measured on the final day of testing. A warm up comprising 10 minutes of light aerobic activity followed by 5 minutes of static stretching for the lower limbs was performed at the beginning of each session [16]. Specific warm ups were performed before the isokinetic strength and vertical jump tests, which are reported below.

Table 1. Anthropometric characteristics of Indian National Football Players

Position	n	Age (years)	Body Mass (kg)	Height (m)	BMI	Body Fat (%)
Defender	10	25.6 ± 0.5	71.5 ± 2.9	1.74 ± 0.04	23.6 ± 0.9	18.2 ± 0.53 [#]
Midfielder	8	24.6 ± 1.8	71.9 ± 1.6	1.71 ± 0.01	24.5 ± 0.6	17.8 ± 0.32 [*]
Forward	10	25.0 ± 0.8	71.9 ± 2.8	1.72 ± 0.03	24.3 ± 1.0	16.0 ± 0.69 ^{#*}
Mean		25.1 ± 1.1	71.8 ± 2.5	1.73 ± 0.03	24.1 ± 1.0	17.3 ± 1.15

Notes: BMI = Body Mass Index

[#] Difference between forward and defender ($p < 0.05$)

^{*} Difference between forward and midfielder ($p < 0.05$)

Anthropometric Measures

Height and body mass were collected using a stadiometer, and electronic scale (Atco, India). Skinfold thickness was measured three times at each site using Harpenden callipers (Lange, Cambridge, MA, USA) and the median of these results was used to estimate the percentage of body fat using the sum of four sites (biceps, triceps, subscapular, and suprailiac) according to previously established methods [17].

Isokinetic Strength Testing

Lower limb strength was assessed for the knee extensors and knee flexors of each player's dominant kicking leg. Maximal isokinetic concentric strength at $60^{\circ}.s^{-1}$ was measured using an isokinetic dynamometer (Kinitech Multi-joint Testing Unit, V5.16, Medisport Engineering, Australia). Prior to testing the participants were given detailed verbal instructions and were familiarized with the protocol performing five submaximal repetitions. During testing the participants were secured in a seated position with the hip and knee flexion set at 90° . The range of movement was set between 90° to 20° of knee flexion and the lateral epicondyle of the femur was aligned with the axis of the dynamometer. Five maximal repetitions encompassing the full range of concentric extension and flexion were collected for each muscle group, with two minutes rest between the repetitions [18].

Maximal Vertical Jump

A jump specific warm up of 5 counter movement jumps increasing the intensity of each jump was performed prior to the test. One minute after the warm up, players performed three countermovement jumps conducted on a piezoelectric force platform (KMS, Australia). During the assessment, all the athletes placed both hands on their hips to avoid any upper body influence on the result [19]. A two minute rest period was allowed between each jump to ensure maximal effort [20]. The highest jump, determined according to flight time, was selected for further analysis.

Yo-Yo Intermittent Recovery Test

The YYIRT was used to assess aerobic capacity and maximal running velocity. This field based test has previously been reported to be a valuable predictor of football performance [21, 22]. Players performed the YYIRT level 1, which commences at a running speed of 10 km.h^{-1} and increases to a maximal velocity of 19 km.h^{-1} [21]. The test involves completing two 20 m bouts of shuttle-running between set markers followed by 10 sec of active recovery (slow jog or walk), with the timing directed by prerecorded acoustic signals. Players were instructed to provide maximal effort to exhaustion however as per protocol the test was terminated if players were unable to maintain the required speed. Distance covered was recorded and used for analysis.

Agility and Sprinting Performance

Agility and sprinting tests were measured using stopwatch due to the unavailability of timing gates. Reliability of this timing method was performed using the 10m sprint since it is the test with the shortest duration and therefore any error in measurement would be

magnified. Intra-class correlation coefficient of 0.95 and a mean difference of 1.3% were found when reliability between two researchers was assessed for the same 15 trials of the 10 m sprint indicating a high level of reliability. Sprint testing was conducted on an outdoor athletic track with the athletes completing three 10 m sprints before progressing to the 30 m sprints. Approximately two minutes rest was allowed between each sprint and during this time the participants walked back to the starting line and waited for the next sprint. To improve reliability of results players performed all tests in triplicate and all tests were conducted by the same investigator positioned on the finish line. Timing commenced upon command, and the watch was stopped when the entire body crossed the finish line.

The agility was assessed using the Illinois Agility Test on an outdoor grass pitch [23]. This test requires players to perform 12 changes of directions while avoiding obstacles at set position [24, 25]. Exact instructions can be found in the research of Miller and colleagues [25]. All participants had prior experience with the test and were afforded a two minute rest period between each attempt. Stance was controlled and each player was informed to begin the agility and sprints from a split stance, leading with their dominant leg. Time to complete each test was recorded and the quickest attempt was used for further analysis [26].

Maximal Ball Kick Velocity

In order to evaluate velocity of a stationary ball, players were asked to kick a ball (FIFA approved), positioned 4 m away from a 1 x 1 m target as hard as possible [27]. Ball velocity was measured with a calibrated radar gun (Bushnell Velocity, USA) located 0.3 m from the ball and pointed directly towards the target. Velocity was recorded at a sampling rate of 25 Hz. Five attempts were allowed per player with one minute rests between each attempt [27]. The strike in which the ball passed through the target zone imparting the highest velocity was selected for analysis. Ball kick velocity was assessed only for the dominant leg of the athlete.

Statistical Analysis

Descriptive statistics were used to determine the characteristics of the players for the entire group as well as for each specific playing positions and are reported as mean and standard deviation of the mean (SD). A one-way ANOVA was used to compare outcomes between the three playing groups and if statistical differences were found Tukey HSD post-hoc test was used to determine where the differences occurred. Pearson product-moment correlations examined the relationships between the anthropometric, physical and physiological variables. Significance was set at an alpha level of 0.05 and all analyses were conducted using IBM SPSS Version 19 (Chicago, IL).

Results

The anthropometric characteristics (Table 1) exhibited very few differences, except for the measure of body fat, which was 2.2% and 1.8% lower in forwards compared to defenders ($p < 0.001$) and midfielders ($p < 0.001$), respectively.

In contrast, most of the physical and physiological measures differed according to playing position (Table 2). Maximal concentric isokinetic strength of the knee flexor was highest for the midfielders followed by forwards and defenders. Midfielders also displayed the greatest knee extension strength which exceeded forwards and defenders by respectively.

Vertical jump performance was similar between defenders and forwards who were able to jump ~18% higher than midfielders. Forwards were ~5% quicker in completing the agility test than both defenders and midfielders but displayed the lowest ball kick velocity (-7%) compared to both groups. Lastly, the midfield players covered significantly more

distance than the forwards (2.5%; $p < 0.001$) and defenders (1.5%; $p = 0.004$) during the YYIRT.

Table 2. Physical and physiological characteristics by playing position

	All Players	Forwards	Midfielders	Defenders
N	28	10	8	10
Vertical Jump (cm)	54.4 ± 5.2	56.4 ± 1.7 *	47.7 ± 3.9 * §	57.8 ± 2.8 §
Ball Kick Velocity (m s ⁻¹)	27.7 ± 1.8	24.48 ± 0.19 #	26.39 ± 2.08 *	26.31 ± 1.92 #
10m sprint (s)	1.90 ± 0.02	1.91 ± 0.01	1.90 ± 0.02	1.90 ± 0.03
30m sprint (s)	4.57 ± 0.05	4.58 ± 0.05	4.57 ± 0.06	4.56 ± 0.05
YTIRT (m)	2030 ± 28	2008 ± 17 *	2060 ± 21 * §	2028 ± 18 §
HR _{max} (bpm)	190 ± 3	189 ± 2	188 ± 4	192 ± 2
Agility (sec)	15.31 ± 0.60	14.78 ± 0.43 # *	15.70 ± 0.23 *	15.53 ± 0.60 #
ISKF 60°.sec ⁻¹ (Nm)	137.1 ± 3.5	133.2 ± 1.7 # *	141.0 ± 1.1 * §	137.8 ± 1.0 # §
ISKE 60°.sec ⁻¹ (Nm)	212.9 ± 4.5	208.2 ± 1.9 # *	218.3 ± 2.2 * §	213.2 ± 2.0 # §

Notes: YYIRT = Yo-Yo Intermittent Recovery Test; HR_{max} = Maximal Heart Rate; ISKF = Isokinetic Knee Flexion; ISKE = Isokinetic Knee Extension

Difference between forward and defender ($p < .05$)

* Difference between forward and midfielder ($p < .05$)

§ Difference between midfielder and defender ($p < .05$)

Examination of the relationships between variables for all players ($n = 28$) revealed that body fat was well related to agility, knee extensor and flexor strength, ball kick velocity, and YYIRT measures (Figure 1). There were some strong correlations between knee extensor and knee flexor strength and jumping performance ($r = -0.57$, $p = 0.002$ and $r = -0.59$, $p = 0.001$), agility ($r = 0.60$, $p = 0.001$ and $r = 0.46$, $p = 0.014$), and ball kick velocity ($r = 0.43$, $p = 0.023$ and $r = 0.43$, $p = 0.023$).

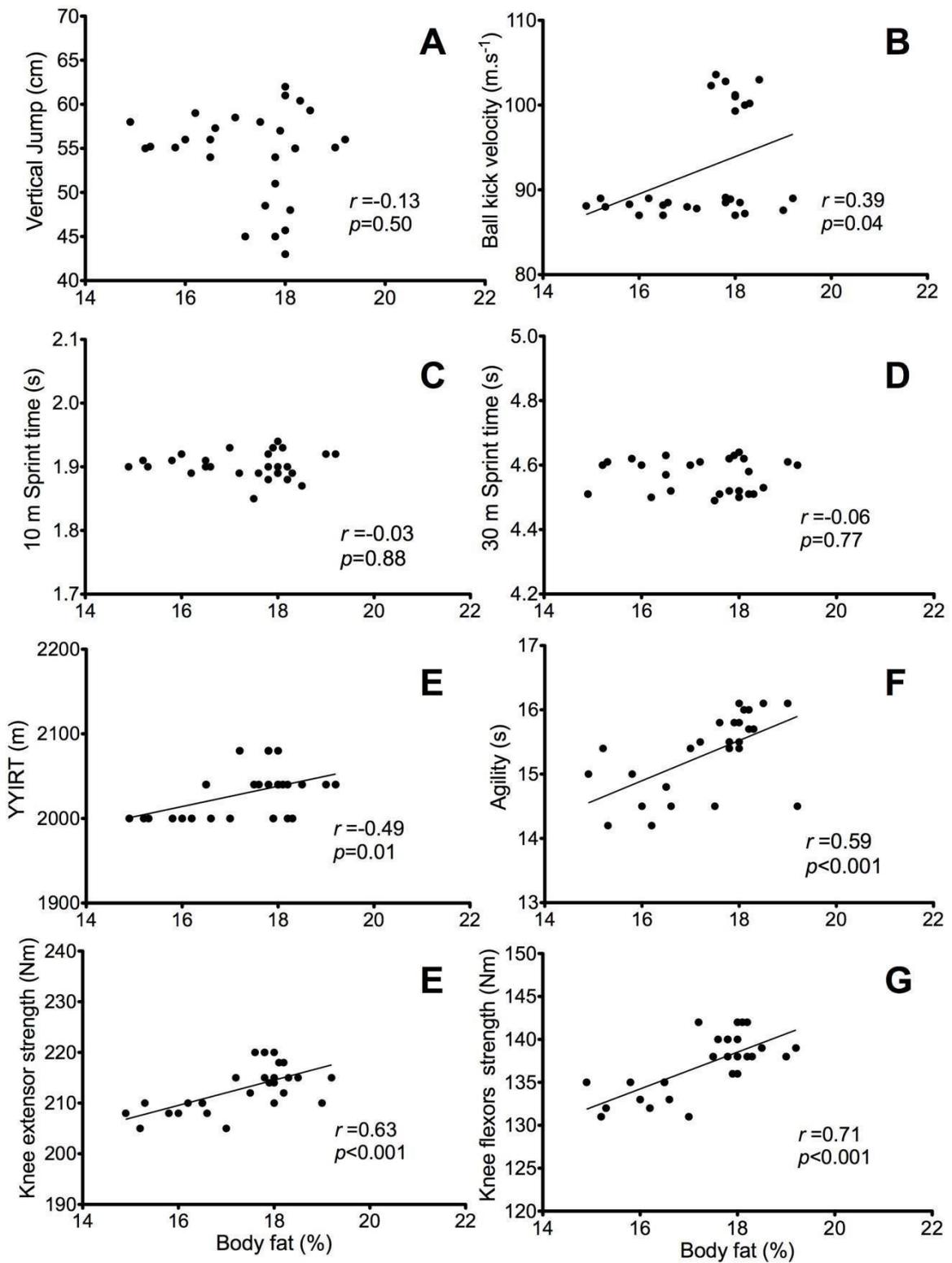


Figure 1. Relationships between percent body fat and performance measures(A) vertical jump, (B) ball kick velocity, (C) 10 m sprint, (D) 30 m sprint, (E) Yo Yo Intermittent Recovery Test, (F) agility, (G) knee extensor maximal strength, and (F) knee flexor maximal strength.

Discussion

Anthropometric, physical and physiological characteristics of players were shown to differ based on playing positions in a sample of elite Indian footballers. This finding confirms previous research performed with European and American footballers and to our knowledge is the first reported data, which has examined these outcomes with Indian national under 22 levels players. The results suggest that more structured training and coaching programs are required as aerobic capacity and body fat results are well below those associated with professionals and is more representative of results reported for the amateur players [21, 28].

Positional differences were found for maximal concentric isokinetic knee flexion and extension strength, agility, and vertical jump performance, suggesting that there are specific positional requirements for players. For example, vertical jump height was about 18% lower for midfielders compared to either defenders or forwards, which may be explained by the fact that they are least likely to need to complete for aerial balls. Similar outcomes have been reported in a cohort of professional Norwegian footballers which demonstrated that midfielders achieved ~12% lower vertical jump height (50.5 ± 4.4 cm) compared to forwards (57.6 ± 5.1 cm) or defenders (55.1 ± 6.5 cm) [29]. Interestingly, in the current study the relationship between knee flexion and extension strength, power, and aerobic performance of players was largely influenced by body composition, particularly excess fat mass. Despite body mass index not differing between the three playing positions (24.1 ± 1.0), body composition was significantly different with attacking players having less body fat (-2.2% ; $p < 0.001$) than defenders and midfielders (1.8% ; $p < 0.001$). Fat mass has been reported to have a negative influence on athletic performance¹⁰ and football research has demonstrated that teams with lower body fat percentages achieve greater success, win more games, and finish higher in elite league competitions [30].

Power is the resultant of force multiplied by displacement divided by time [31], the ability to achieve more force over the same distance and time period would increase power. Therefore, increasing strength should translate to increased power in professional athletes [9]. The current study found that players who generated the fastest ball kick velocity were not able to produce high muscular power during the vertical jump or agility performance. However, there was a strong and significant relationship between ball velocity and the 10 m ($r = -0.715$) and 30 m ($r = -0.744$) sprint time suggesting that explosive kicking velocity was well related to acceleration needed to succeed in the sprints. These findings provide some potential training modifications suggesting that coaches and sports scientist should incorporate horizontal, lateral, and loaded vertical jump training as well as specific change of direction training as reported by Brughelli and colleagues [24].

It could be expected that stronger players would have greater capacity to generate power (explained above) such as greater vertical jump height. Our results displayed however a negative relationship between maximal knee flexion ($r = -0.57$), maximal knee extension ($r = -0.59$) and jump height. This may be attributable to the relatively large percentage of body fat found in the current cohort. Metaxas and colleagues reported that body fat in football players decreases relative to the number of years of training and decreasing fat mass can enhance a players performance [10]. The majority of players in this study were fairly young, current or past Indian under 22 national players, which may account for the high level of body fat due to fewer years of professional training. In contrast to the Indian players (body fat = $17.6 \pm 1.6\%$), Spanish and Portuguese professional footballers have been reported to have 8 – 11% body fat and Premier league teams in England approximately 13% body fat [32]. However, the players in the current study even exceeded the body fat percentage reported for elite under 20 Greek national footballers (14.8%) [10]. Since the Greek players were assessed for body fat percentage using the same measurements and methodology the results appear to

discount the young age of the Indian players and suggests further that training intensity and load may be too low or that further nutritional guidance is required for these players.

The negative relationship between vertical jump and agility and the positive relationship between ball velocity and vertical jump appear to be influenced by the mass of the player's body segments as well as fat mass. The relationship between agility and body fat ($r=0.59$) demonstrates that increased fat mass will result in a longer time taken to complete the agility run. Forwards who carried least body fat produced the quickest agility times, confirming this relationship. Further, body fat was well correlated with ball velocity most likely due to the inertia imparted on the ball, which leads to increased change in its momentum illustrated by its velocity.

Midfielders were able to cover 2.5% and 1.5% more distance during the YYIRT than both forwards and defenders, respectively. This suggests that midfielders had a slightly higher aerobic capacity than their teammates and is likely due to the additional volume of work that they are required to perform during competitive matches. Interestingly, this resulted in a positive relationship between percent body fat and the YYIRT which was due to the midfielders' characteristics of having the greatest percentage fat and covering the most distance during the YYIRT. However, previous findings have reported that the distance covered during an elite Australian football match was similar between midfielders and attackers that both playing positions covered significantly more distance than defenders¹³. Furthermore, the aerobic capacity measured during a maximal graded exercise test was no different between professional Norwegian midfielders or forwards [29]. These studies suggest that attacking players within the Indian professional system are not sufficiently fit enough to complement the capacity of their midfield counterparts. However, the total distance covered during the YYIRT (2030 ± 28 m) was below that of anthropometrically similar but amateur players (2138 ± 364 m) [21], indicating that coaches and sport scientists need to dedicate more time and effort to increasing the cardiorespiratory fitness of elite Indian football players. Reilly³² has reported that teams training at a higher intensity have a competitive advantage over teams with lower fitness levels that are equally as skillful. Therefore, apart from enhancing sport specific skills improving aerobic fitness should be the primary goal for this group.

This study provides initial anthropometric, physical and physiological results of elite footballers in India. It is evident that these performance measures are below previously published findings of other international and professional football players. Therefore, the outcomes are not intended to be utilized as normative data of Indian footballers, but rather as a foundation around which coaches, sports scientists and other professionals can begin to develop effective training programs. These results suggest that the current frequency and intensity of training may need to be increased with a primary goal of enhancing aerobic fitness while simultaneously developing strength and power using structured resistance training.

Conclusion

In conclusion, the current study assessed a cohort of elite Indian footballers. Significant differences were found for performance characteristics across different positions. These novel characteristics are likely due to the nature of the game. For example attackers and defenders compete for more aerial possession and therefore need greater vertical jump ability than midfielders. However, the most notable findings from this study are that professional Indian footballers are not aerobically fit enough when compared to other international players and possess a greater percentage of body fat than other professional footballers. This paper reports initial profiling characteristics for elite Indian football players, however to become

internationally competitive these athletes will need to modify their profiles in line with elite European and American football players.

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