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Original Article

Body composition characteristics and physiological performance tests of junior elite field hockey players according to different playing positions

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Abstract:
Cellular level body components and their impact on functional performances are still unclear in team sports. We aimed to investigate the position specific characteristics of cellular level body composition and physiological parameters and their inter-relationships among junior elite field hockey players (mean age, 16.2 ±1.87 yrs). One hundred ten (N=110) male field hockey players from different playing positions (Goalkeeper, n=15; Defender, n=39; Midfielder, n=32; Forward, n=24) were evaluated at end of the preparatory phase. Whole body bio-electrical impedance analysis (BIA) was performed using a multi-frequency analyzer (Maltron Bioscan 920-2, Maltron International, Rayleigh, Essex, UK). FFM and TBW were calculated using Asian based prediction equations from manufacturer's software. Thereafter, maximal isometric grip & back strength, trunk flexibility and 20 meter shuttle test (bleep test; for VO_2 max) were conducted followed by standard procedure.
One-way ANOVA showed significant differences ($p<0.01$) in anthropometric indicators and body composition parameters (Glycogen mass, Muscle mass, BCM, ECM: BCM, BCM/FFM%, Total Mineral Mass, TBW, ICW, ICW%, ICW/FFM%) with respect to field positions. Forwards possessed highest levels of active body tissue development and the most efficient cardiovascular systems. Defenders displayed larger body build, while midfielders exhibited significantly ($p<0.01$) higher values of body cell mass along with superior hydration status relative to body weight. Goalkeepers demonstrated different physical and physiological characteristics from outfielders. Linear regression analysis revealed that both TBW and ICW were the key parameters having significant positive relation ($p<0.05$) with functional performances.
There are qualitative and quantitative alterations between assessed positions and the correct use of these individual differences on behalf of the team can contribute to the sportive success. Loss of ICW but not TBW could be the risk of decreasing upper body strength. Relative BCM, ECM/BCM, BCM/FFM and BCMI needs wide scale application in team sports.
Key words:bio-electrical impedance, body cell mass, intra cellular water, physiological performances, young field hockey players.

Introduction:

Field hockey is a team sport with heavy demands on the player's physiology (Reilly and Borrie, 1992; Spencer et al., 2004). Game play requirements over the past few years have undergone quite rapid and radical changes. Introduction of artificial pitches as the official playing surface has been shown to increase the effective playing time of games (Reilly & Borrie, 1992), increase the number of ball touches per player (Hughes, 1988), players ran with the ball further and more often (Malhorta et al, 1983) and hence increase the energy cost of running (Reilly & Seaton, 1990) and the physiological requirements of games compared to games played on grass (Malhorta et al, 1983). The introduction of ball boys and the abolishment of the 'off-side' rule may mean that the ball is in play longer and that defending teams can not negate space on the pitch therefore increasing attacking space and led to more goals being scored per match. Finally, the introduction of the 'roll-on roll-off' substitutions allow unlimited substitutions (a maximum of 16 players can play in each match and can rotate as frequently as they like) which may have increased the intermittent nature of the sport with players performing at very high intensities for relatively short bouts of time with complete rest between each intermittent period of activity. In 2009, the auto-pass was introduced which allows quick and immediate play from a free hit. Spencer et al. (2004) explain that these changes were initiated to promote fast-paced, continuous play. These changes have altered the tactical and physiological demands of the game.

The positions of hockey can be divided into four categories; goalkeepers, defenders, midfielders and forwards and each have specific roles and activities. Players carry out all sorts of explosive actions such as intermittent sprinting with many changes of direction, cruising, and dribbling the ball, placing it in the category of ''heavy exercise'' (Patel et al., 2002). The absolute number of high-intensity efforts and total distance covered in these activities has been reported greater in midfielders than strikers and defenders (Gabbett, 2010).

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Hockey players playing in different positions found to differ on some anthropometric measurements and body composition (Karkare, 2011). Stature and body mass have significant impact on elite hockey teams (Reilly and Borrie, 1992). Tall players have an advantage in playing positions such as goalkeeper, forward and defence. In addition to this data, a select few have specifically studied and provided information on the physical characteristics such as body mass, height, body fat percentage and body mass index of elite and sub-elite players (Holway and Seara, 2011; Calo et al., 2009; Manna et al., 2011). Recently body composition analysis by impedance method showed higher Fat% for the backs/goalkeepers and lower for forwards group whereas opposite results were obtained for muscular mass (Calo et al., 2009).

To assess body composition, bioelectrical impedance has gained importance both in health and sport fields. The 'Maltron BioScan 920' is one of the devices, which has shown a better relation with other type of techniques (viz., DEXA), in athletes, being a reliable tool for this purpose (Vujkov et al., 2015). In Indian context, recently, study on body composition at cellular level using whole body impedance method has been conducted especially in a group of different athletes (Bandyopadhyay et al., 2018) and also in women soccer players comparing different training phases (Dey et al., 2015).

Hockey players require high aerobic and anaerobic power, good agility, joint flexibility and muscular development, and are capable of generating high torques during fast movements (Reilly et al., 2000). A lean body is desirable for sports like field hockey (Montgomery, 2006). As performance this sport requires one to carry one's body weight over a distance, which is facilitated by a large proportion of active tissue (muscle) in relation to a small proportion of fat tissue (Jain, 2004). Different demands on particular field positions are reflected in different body composition of these players. For as it has been shown, this monitoring has a direct relation with the typical actions from team sports (Gil et al., 2007). In addition to methods per se, variation in body composition influences the functional capacities and performances of athletes in many sports. Due to the ever increasing physical requirements and differing demands of specific positions within the sport, it is advisable to verify association of body composition with both general and specific motor tests.

Very limited data exist in athletes with regard to Level III (cellular), which provides details about cellular mass, extracellular fluids and solids. Moreover, no published literature yet has been reported considering the relationship of cellular level body composition and physiological performances in young field hockey players of different playing position. The aim of this study was twofold; (1) to explore positional differences within age group and (2) to assess the relationships between body composition and functional parameters.

Material and methods:

One hundred and ten (N=110) young male soccer players (mean age; 16.2 ±1.87 yrs) were participated in the study. All the players were belonged from various schemes of Sports Authority of India (SAI), eastern region. The players of the present study were at least of state level performer with minimum of 3-4 yrs of formal training history with no history of any hereditary and cardio-respiratory diseases. All the subjects were belonged to almost same socio-economic status, having similar dietary habits and were having training in same kind of environmental/ climatic condition. Hence, they were considered as homogeneous.

Training Regimen:

The training programme was designed by the coaches of SAI & it consisted of two consecutive training protocols which include 8 weeks pre-season and 4 weeks competition training. The physical training schedule includes different strength and endurance training program along with flexibility exercises. The training sessions were followed an average of 4 to 5 hours every day except Sunday (about 30 hours in a week), according to the requirements of the game and competitive demand. Pre-season training was consisted of a progressive aerobic training program for improvement in the endurance capacity. The sessions comprised four 6 min runs at 90% maximal effort, separated by 2 min rests for the first 4 weeks and four 8 min runs at 90% maximal effort, separated by 2 min rests for the remaining 4 weeks. Competitive training season was consisted of three sessions each week: two aerobic training sessions consisting of five 3 min runs at 100% maximal effort, separated by equal rests, which were followed by technical development training designed to improve game specific skills; a third session was comprised of a practice game. Two training sessions and a competitive match were performed each week during the competitive season; the training sessions were also comprised small-sided games of approximately 45 min aimed at developing physical fitness, followed by ~95 min of technical and tactical practice. Warm up & cool down session after & before starting the main practice were also included in the programme. Besides the technical and tactical training the players were also provided psychological or mental training session.

Before the commencement of test all the subjects were clinically examined by the specialized physicians of Sports Medicine following standard procedure (SAI, National Sports Talent Contest Scheme, 1992). The subjects were finally evaluated at the end of their competitive phase for various anthropometric, body composition and physiological variables at Human Performance Laboratory of Sports Authority of India, Kolkata.

Measurement procedure:

The decimal age was calculated from the date of birth recorded from original birth certificate, produced by the subjects at the time of testing. The physical characteristics including height (to the nearest 0.1 cm) and weight (to the nearest 0.1 kg) were measured by digital stadiometer (Seca 242, Itin Scale Co., Inc., USA) and body composition analyzer (Tanita BF-350, Tanita Corporation of America Inc., USA) respectively.

Multi Frequency Bioelectrical Impedance Analysis (MF-BIA):

Total body electrical impedance to an alternate current (0.2 mA) with four different frequencies (5, 50, 100 and 200 KHz) was measured using a multi-frequency analyzer (Maltron Bioscan 920- 2, Maltron International, Rayleigh, Essex, UK) following the standard testing manual of Maltron International (Maltron Bioscan 920-2 operating and service manual. 1999).

Prior to the measurement, the subjects were given instructions according to the following guidelines of Heyward & Stolarczyk (1996): 1) no intake of alcohol 48 hours before the test; 2) no heavy exercise 12 h before the test; 3) no large meals & intake of caffeinated products 4 h before the test; 4) no intake of diuretics for 7 days before the test and 5) consumption of liquids limited to 1% of body weight, or, two 8-oz. glasses of water, 2 h before the test.

Maximal isometric grip strength:

After body composition was assessed, maximal isometric grip strength was determined using a digital handgrip dynamometer (Takei A5401, Takei Scientific Instruments Co., Ltd., Niigata City, Japan) with visual feedback. The detailed testing procedures have been reported elsewhere (Waldo, 1996).

Maximal isometric back strength:

Maximal back strength (BS) was measured using a back muscle dynamometer (Takei A5402, Takei Scientific Instruments Co., Ltd., Niigata City, Japan). The detailed testing procedures have been reported elsewhere (Bosco and Gustafson, 1983).

Trunk flexibility Test:

The flexibility was assessed by the sit and reach box that was first described by Wells and Dillon (1952). That test measures the flexibility of the lower back and hamstrings.

20 Meter Shuttle Test (20 MST, Bleep Test):

The 20 MST protocol required the subjects to run alternately back and forth across a 20-m distance as described by Leger et al. (1988). This testing took place in an open synthetic Astroturf.

All the tests were conducted at a room temperature varying from 23 to 25 degree centigrade with relative humidity varying between 50- 60%. On the other hand these parameters were varied in the field around 18-28 degree centigrade with 65-75% relative humidity respectively.

Ethical Consideration:

The present study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Ethical Committee of Sports Authority of India, Kolkata. Prior to initial testing, a complete explanation of the purposes, procedures and potential risks and benefits of the tests were explained to all the subjects and a signed consent was obtained from them.

Statistical Analysis:

Mean, standard deviations (±SD) for all the selected variables were calculated. The assumption of normality was verified using the Shapiro-Wilk W-test. One way ANOVA followed by Bonferroni's post-hoc test for the multiple comparisons among the selected variables was performed. The significance level was defined as $p<0.05$ (two-tailed). Result of regression analysis were plotted along the 'line of equality' (i.e. the line at a 45^0 angle) to visually examine the concordance in the scatter plots. Data was analyzed using the Statistical Package for Social Science (version 21.0, SPSS, Inc., Chicago, IL , 2012).

Results:

Table I represents the comparison of mean for the general physical characteristics of the soccer players according to their playing positions. Comparatively bigger size was evident for the goalkeepers in contrast to their outfield counterparts. On the other hand, Bonferroni's post-hoc test revealed that attackers (forward) were significantly smaller (both in height and weight, at the level of $p<0.01$) than goalkeepers and defenders. Attackers were also evident by lowest BMI and BF%, however, no such significant difference observed in case of these parameters.

Table I. Mean, standard deviation and level of significance of general physical characteristics of the players according to playing position.

Variables	Goalkeeper (n=15)	Defender (n=39)	Midfielder (n=32)	Forward (n=24)	F	Bonferroni's Post-hoc Test
Age (yrs)	17.2 ±1.73	16.0 ±1.80	15.9 ±1.97	16.3 ±1.80	2.03^{ns}	
Height (cm)	170.8 ±3.34	170.5 ±4.75	168.1 ±4.63	167.1 ±3.90	4.28**	DF vs FW**
Weight (kg)	61.0 ±5.89	59.9 ±6.49	56.4 ±5.52	54.9 ±5.24	5.68**	FW vs GK*, DF**
BMI ($kg.m^{-2}$)	21.1 ±2.20	20.6 ±1.81	20.0 ±1.68	19.8 ±1.79	2.01^{ns}	
BF (%)	12.4 ±3.35	13.9 ±4.56	13.2 ±3.34	12.2 ±4.22	1.04^{ns}	

Values are (mean ± SD). Significant differences between groups: **P< 0.01,* P< 0.05, ns= not significant (one-way ANOVA followed by Bonferroni's post hoc test). GK= Goalkeeper, DF= Defender, MF= Midfielder, FW= Forward.

Table II represents the comparison of mean for the lean body composition of the soccer players according to their playing positions. Fat free mass and glycogen mass were significantly higher ($p<0.01$) both in goalkeepers and defenders than midfielders and attackers. Muscle mass and ECM was higher significantly ($p<0.01$) in goalkeepers than midfielders and attackers. On the other hand, BCM was significantly ($p<0.01$) lowest in attackers than both goalkeepers and defenders. In case of ECM:BCM, ECM%, ECM/FFM % and Cell Quality (CQ; BCM/FFM %); goalkeepers exhibited significantly highest value ($p<0.01$) over their outfield counterparts. No such significant difference was observed in BCM% and BCMI among the groups. TBK, TBCa and total mineral mass was found to be highest in goalkeepers and defenders whereas lowest for the midfielders and attackers. However, the significant differences ($p<0.01$) were existed only for TBK and total mineral mass.

Table II. Mean, standard deviation and level of significance of lean body composition and mineral status of the players according to playing position.

Variables	Goalkeeper (n=15)	Defender (n=39)	Midfielder (n=32)	Forward (n=24)	F	Bonferroni's Post-hoc Test
FFM (%)	89.6 ±2.43	86.6 ±4.80	86.8 ±3.86	86.7 ±4.43	2.04 ns	
FFM (kg)	54.6 ±4.82	51.8 ±6.30	48.9 ±5.48	47.7 ±5.90	5.89**	GK vs MF*, FW**; DF vs FW*
Glycogen mass (gm)	496 ±43.69	472 ±56.23	446 ±48.81	434 ±53.23	5.91**	GK vs MF*, FW**; DF vs FW*
Muscle mass (kg)	26.4 ±2.45	25.0 ±3.17	23.7 ±2.75	23.3 ±2.83	4.82**	GK vs MF*, FW**
ECM (kg)	26.0 ±2.46	23.8 ±3.59	22.4 ±3.05	21.8 ±3.28	6.27**	GK vs MF**, FW**
BCM (kg)	28.6 ±2.40	28.0 ±3.07	26.5 ±2.58	25.9 ±2.78	4.87**	FW vs GK*, DF*
ECM : BCM	0.91 ±0.03	0.85 ±0.08	0.84 ±0.06	0.84 ±0.06	4.02**	GK vs DF*, MF*, FW*
ECM (%)	42.6 ±1.35	39.8 ±3.66	39.7 ±2.78	39.6 ±3.37	3.61**	GK vs DF*, MF*, FW*
BCM (%)	47.0 ±1.35	46.8 ±2.44	47.1 ±1.90	47.1 ±1.53	0.15 ns	
ECM/FFM (%)	47.5 ±0.67	45.9 ±2.40	45.7 ±1.68	45.6 ±1.85	3.71**	GK vs DF*, MF*, FW*
CQ (%)	52.5 ±0.66	54.1 ±2.43	54.3 ±1.70	54.4 ±1.85	3.73**	GK vs DF*, MF*, FW*
BCMI	9.8 ±0.86	9.6 ±0.91	9.4 ±0.81	9.3 ±0.83	1.87 ns	
TBK (gm)	137.0 ±11.58	133.6 ±14.81	126.2 ±12.70	123.5 ±13.48	4.93**	FW vs GK*, DF*
TBCa (gm)	1014 ±122.31	959 ±168.48	922 ±139.35	925 ±142.07	1.58 ns	
Total Mineral Mass (kg)	4.2 ±0.47	3.8 ±0.74	3.6 ±0.52	3.5 ±0.48	5.22**	GK vs MF*, FW**

Values are (mean ± SD); **P< 0.01,* P< 0.05, ns= not significant. N. B.: FFM-fat free mass; ECM-extra cellular mass; BCM-body cell mass; CQ-Cell Quality; BCMI-body cell mass index.

Table III represents comparison of mean for the hydration and mineral status of the soccer players according to their playing positions. Total body water including extracellular and intracellular spaces were found to be significantly ($p<0.01$) greatest in goalkeepers whereas significantly ($p<0.01$) lowest both in forward and midfielders. ECW/ICW, on the other hand was found to be significantly ($p<0.01$) highest in goalkeepers than rest of the playing positions. In case of relative TBW (both to body weight and FFM), no such significant differences was observed among the field positions. Relative ECW (both to body weight and FFM) was found significantly ($p<0.05$) highest in goalkeepers whereas lowest in midfielders. On the other hand, relative ICW (both to body weight and FFM), was found to be significantly ($p<0.05$) highest in goalkeepers compared to defenders and midfielders.

Table III. Mean, standard deviation and level of significance of hydration status of the players according to playing position.

Variables	Goalkeeper (n=15)	Defender (n=39)	Midfielder (n=32)	Forward (n=24)	F	Bonferroni's Post-hoc Test
TBW (lt)	38.4 ±3.24	37.2 ±4.46	35.2 ±3.79	34.3 ±4.23	4.63**	FW vs GK*, DF*
ECW (lt)	16.2 ±1.81	14.2 ±2.86	13.3 ±2.66	13.2 ±2.92	4.87**	GK vs MF**, FW**
ICW (lt)	22.2 ±1.50	22.9 ±2.30	21.9 ±1.75	21.1 ±1.75	4.70**	DF vs FW**
ECW/ICW	0.73 ±0.05	0.62 ±0.11	0.61 ±0.11	0.62 ±0.11	5.11**	GK vs DF**, MF**, FW*
TBW (%)	63.1 ±2.85	62.2 ±4.57	62.5 ±3.92	62.4 ±3.59	0.19 ns	
ECW (%)	26.5 ±1.79	23.7 ±3.65	23.5 ±3.74	23.9 ±3.85	2.80*	GK vs MF*
ICW (%)	36.5 ±1.80	38.4 ±3.06	38.9 ±2.00	38.5 ±1.66	3.71**	GK vs DF*, MF**
TBW/FFM (%)	70.4 ±1.56	71.8 ±3.69	72.0 ±2.29	72.0 ±1.67	1.33 ns	
ECW/FFM (%)	29.6 ±1.40	27.3 ±2.98	27.0 ±3.20	27.4 ±3.20	2.98*	GK vs MF*
ICW/FFM (%)	40.8 ±1.52	44.5 ±4.36	44.9 ±3.03	44.6 ±3.29	5.50**	GK vs DF**, MF**, FW**

Values are (mean ± SD); **P< 0.01,* P< 0.05, ns= not significant. N. B.: TBW-total body water; ECW-extra cellular water; ICW-intra cellular water; TBK-total body potassium; TBCa-total body calcium

Table IV represents comparison of mean for the physiological profiles of the soccer players according to their playing positions. Although insignificant, in case of maximal isometric grip strength & back strength, goalkeepers showed superior values among the groups whereas inferior values were observed both in midfielders and forwards. Attackers found with higher relative back strength whereas similar values were noted for rest of the groups. Trunk flexibility found greatest for the goalkeepers whereas similar VO_2max level was observed in four different groups. No such significant difference was observed among the groups in case of any parameter.

Table IV. Mean, standard deviation and level of significance of functional profiles of the players according to playing position.

Variables	Goalkeeper (n=15)	Defender (n=39)	Midfielder (n=32)	Forward (n=24)	F	Bonferroni's Post-hoc Test
Grip$^{(R)}$ Strength (kg)	40.8 ±4.57	40.2 ±4.87	40.2 ±4.22	38.9 ±5.45	0.61^{ns}	
Grip$^{(L)}$ Strength (kg)	40.1 ±6.31	40.1 ±4.91	39.2 ±5.06	40.0 ±6.26	0.21^{ns}	
Back Strength (kg)	112.4 ±16.48	112.5 ±16.65	107.6 ±16.13	107.6 ±17.75	0.76^{ns}	
Relative Back Strength	1.9 ±0.25	1.9 ±0.23	1.9 ±0.27	2.0 ±0.27	0.71^{ns}	
Trunk Flexibility (cm)	14.8 ±6.51	14.4 ±3.97	13.7 ±4.04	11.7 ±4.08	2.25^{ns}	
VO_2max ($ml.kg^{-1}.min^{-1}$)	60.6 ±4.87	58.9 ±5.18	59.9 ±4.48	60.5 ±5.42	0.68^{ns}	

Values are (mean ± sd); **P< 0.01,* P< 0.05, ns= Not Significant.

Distribution of points for the measured physiological characteristics with body composition variables is shown by linear regression plot in **Fig. I**.

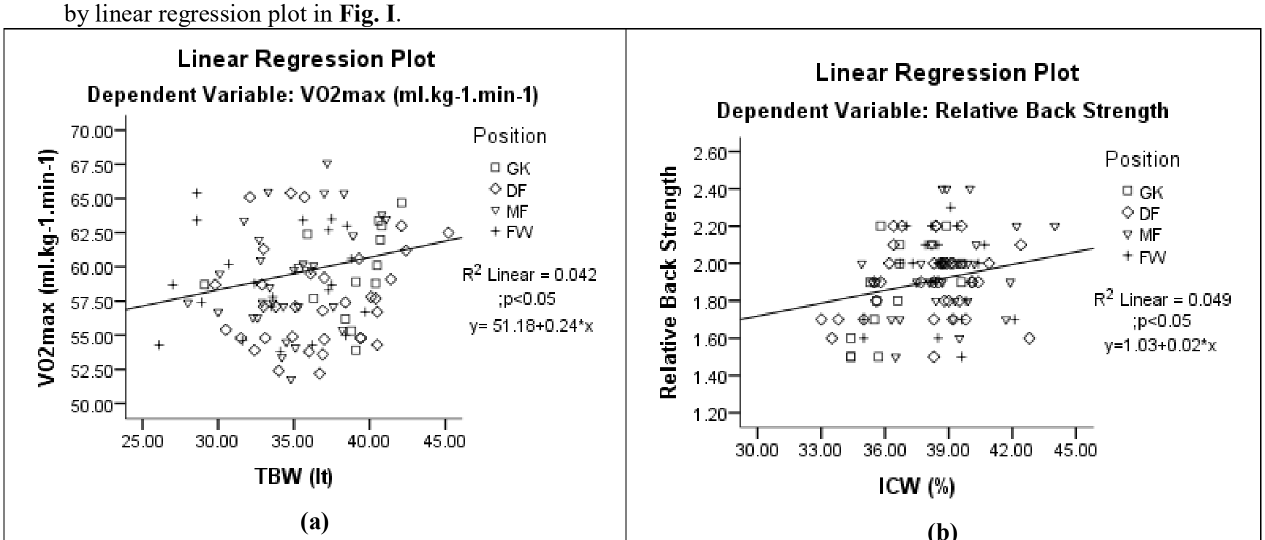

Fig. I:*Relationship between- (a) VO_2max ($ml.kg^{-1}.min^{-1}$) and TBW (lt); (b) Relative Back Strength and ICW (%). Characteristics of the regression line are given in the plots. GK= Goalkeeper, DF= Defender, MF= Midfielder, FW= Forward.*

Discussion:

Changes in quality and quantity of the imposed training load and/or training state is better reflected by body composition than the maximal functional variables. Inter-individual variability in body composition and functional parameters of junior field hockey players according to different playing positions were examined in the present study.

The mean height and weight of present hockey players (as described in Table I) was well comparable with the values of university level players (169.1 ±5.7 cm; Sharma et al., 2012; 170.1 ±5.7, cm and 63.2 ±6.9 kg, Koley and Kar, 2017), U19 national players (170.3 ±3.4 cm and 60.7 ±3.7 kg, Manna et al., 2010) and Singapore National players (170 ±0.8 cm and 61.2 ± 5.6 kg; Aziz et al, 2000) of previous reported studies. On the other hand, our players were slightly smaller in size than Indian senior national players (171.7 ± 5.8 cm and 60.9 ± 4.8 kg; Ghosh et al, 1991). In accordance with the previous findings (Holway and Seara, 2011; Koley and Vashisth, 2014), present goalkeepers were seen to be heaviest and tallest than the outfielders.

The body composition is a very important aspect to the physical ability level, as the fat surplus can substantially decrease the human performance. The present hockey players showed much lower BF% value according to different positions than earlier reported data of national players (Koley and Vashisth, 2014: goalkeepers 17.9 ±3.8%, defenders 14.8 ±2.7%, midfielders 16.9 ±4.7%, forwards 15.4 ±2.5%). Although, in the present study, no differences were observed in BF% among the assessed positions however, in accordance with previous study of Sharma et al. (2012), goalkeepers showed a higher BMI, greater BF% and muscle mass in contrast to other positions. Lower value in fat% and muscle mass of present midfielders/forwards represents developed skill in aerobic and anaerobic system and particularly a light, reactive body which was highlighted in a previous study (Malhotra et al, 1974).

In field hockey, grip strength is important in handling the stick during execution of different skills while upper body strength allows players to shoot more powerfully and pass over a greater range of distances. Present hockey players have superior hand grip strength values (as described in Table IV) than the university and national level players of previous studies (36.0 ±4.9/36.6 ±4.7 kg, Sharma et al., 2012; 35.8 ±1.5 /31.8 ±1.4 kg, Manna et al., 2009; 35.2 ±1.9/32.4 ±1.7 kg, Manna et al., 2010). Although there is a lack in research worldwide, however, in a previous study, South African players reported much higher grip strength (54.0 & 53.1 kg; Scott, 1991). Back strength data for the present players was well comparable with U19 national level players (113.3 ± 3.9, kg; Manna et al., 2010) of previous study. Both defenders and forwards showed higher strength values than the midfielders and goalkeepers. According to different positions, however present hockey players exhibited poorer back strength values than earlier reported data of national players (goalkeepers 129.2 ±13.2 kg, defenders 117.7 ±12.7 kg, midfielders 124.2 ±19.5 kg, forwards 123.0 ±20.7 kg; Koley and Vashisth, 2014).

Present players also showed slightly lower trunk flexibility values according to different positions compared to previous data (Koley and Vashisth, 2014: goalkeepers 16.4 ±1.9 cm, defenders 15.0 ±1.7 cm, midfielders 15.3 ±1.8 cm, forwards 15.0 ±2.8 cm). In our study, however, it was the defenders who have the highest flexibility measure whereas forwards have shown lowest value. Due to lack of literature, present flexibility measures could not compare with international counterparts.

Although the present mean VO2 max (as described in Table IV) was lower compared to West Germany national players and English players (63.5 ml kg-1 min-1 and 62.2 ml kg-1 min-1 respectively; Reilly and Borrie, 1992), however, was well comparable with Spanish national hockey players (59.7 ml kg-1 min-1; Reilly and Borrie, 1992) and Canadian elite field hockey players (59.2 ml kg-1 min-1; Montgomery, 2006). On the other hand, our young players exhibited higher mean value than U19 national players (57.0 ±3.9, ml.kg-1.min-1, Manna et al., 2010), senior national players (53.8 ±9.1 ml kg-1 min-1, Ghosh et al, 1991), Australian elite players (57.9 ±3.6 ml kg-1 min-1, Scott, 1991), Singapore National players (57.8 ±6.2 ml kg-1 min-1, Aziz et al, 2000) respectively. Present forwards found with highest VO2 max whereas lowest mean value was exhibited by the goalkeepers. On the other hand, almost similar value noticed between defenders and midfielders. Literature addressing aerobic capacity of young male hockey players according playing position is extremely limited. However, it has been well reported (Spencer et al., 2004) from the motion data that inside forwards and strikers played the most match time (18 min more than the half-backs) and perform higher number of sprints (39 ±1 and 42 ±15, respectively) than the fullbacks and halfbacks (18 ±1 and 22 ±7, respectively).

Components of lean body mass are needful in monitoring changes at the cellular level. Intracellular mass (or BCM) is composed of all cells which are able to utilize oxygen, i.e. cells participating in the movement. Monitoring of lean body mass components (intracellular and extracellular mass), eventually total body water components (intracellular and extracellular water) is very important in comparison of changes during a short-term intervention, in which estimation of lean body mass, muscle mass and fat mass values do not changes.

Although no direct study available for cellular level assessment of body composition in field hockey players, however, variation in the values of BCM content among present field hockey players according to different playing positions (as described in Table II) are also in agreement with the findings of previous studies of young soccer players (Burdukiewicz et al., 2013; Mala et al., 2015). According to Burdukiewicz et al. (2013), the differences in BCM reflect varied level of physical performance in athletes. In order to reduce the effect of body weight, we have expressed the absolute BCM value relative to the body weight (BCM, %). Similar values for BCM% reflect that in modern field hockey, each outfield player assumes a larger role in the overall play of the team, so the positional differences are less than previously seen (Koley and Vashisth, 2014).

ECM/BCM for evaluation of physical exercise prevalence was further confirmed as the only significant difference was registered among goalkeepers and outfielders in present study. In accordance with the findings of Mala et al. (2015) highest value for this index was found in our goalkeepers. On the other hand, an interesting value of lean body mass appeared in midfielders, when significance of the difference in body weight between midfielders and goalkeepers has not been shown. This difference may be due to accretion of BCM, which was associated with quality of imposed training load and with an increase of ICW (Roche et al., 1996).

BCM as per FFM indicates a high quality of LBM in players, when the mean value of our players (CQ= 54.0%) crossed the limit of the recommended 50% of BCM proportion in LBM (Data Input, 2004). A significant lowest CQ and highest ECM/FFM% content in goalkeepers compared to their outfield counterparts reflects position specific physiological demand among the different playing positions. On the other hand, body cell mass index (BCMI) has been proved to be more sensitive than BMI in revealing differences of muscular mass. Highest body cell mass was observed in goalkeepers while taking body height into consideration. The obtained results may be further justified by the observed ascendency of the muscle mass among the groups.

In field hockey, players carry out all sorts of intermittent and explosive actions categorized as ‘‘heavy exercise’’ (Patel et al., 2002). The more active its metabolism, more water is required to perform the chemical reactions associated with vigorous activities of muscle (Lang et al, 1998). According to Mala et al. (2008), a high proportion of fat free mass (FFM) relates to a high volume of TBW and its ICW component. Subsequent increases of ICW (56.4% of TBW in female and 59.6% in male) correspond to an increase of active mass and musculature. On the other hand, ECW is composed of water in support and transport tissues which may not be related to muscle strength. Both goalkeepers and the defenders have lower metabolic energy cost both in gaming days and along training sessions than players of other positions (Liu et al., 2013). Although goalkeepers and the defenders in the present study found with greater absolute water volume (as described in Table III), however, they exhibited poorest content of relative body water spaces (including both ECW and ICW). In case of both midfielders and forwards, greater level of hydration is due to the fact that they appear to engage in moderate to high intensity activity more frequently, and for longer durations (Liu et al., 2013). This fact was further justified by the result as significant correlation found between hydration level and aerobic capacity (Fig. Ia). Again, an increased TBW is predominantly due to an increment in ICW compartment. More recently, Silva et al. (2014) found that although mean ICW did not change in elite basketball, handball & volleyball players in their study, but those players who increased the ICW pool increased strength and jumping performance from the beginning to the main competitive periods. This fact was further justified by our result as relative back strength was strong and significantly correlated with ICW % (Fig. Ib).

Although the exact physiological basis linking cell hydration with an anabolic drive is yet to be determined, however, evidence shows a correlation between cellular hydration with both an increase in protein synthesis and a decrease in proteolysis (Haussinger et al., 1993). Moreover, glycogen has an osmotic effect whereby it draws three grams of water into the cell for every gram of glycogen (Chan et al., 1982). Previously, an increased glycogen store reported to mediates a favourable muscle protein balance over time (Chan et al., 1982).

Conclusion:

Very few differences were observed among the three outfield groups i.e., defenders, midfielders, and forwards in our screened sample. Goalkeepers demonstrated higher physical characteristics, and bodycomposition parameters from outfield players. Forwards were characterised by their highest levels of active body tissue development and the most efficient aerobic capacity. Defenders displayed larger body build, while midfielders were characterised by significantly higher values of relative body cell mass.

Differences in BCM, relative BCM, ECM/BCM and CQ could be the potential indicators for evaluation of qualitative and quantitative alterations in the imposed training load of different playing positions. On the other hand, TBW alters due to different sports activities and increases with physiological capacities. ICW was the only component was significantly associated with physiological variables despite of different field positions.

Physiological characteristics among the playing positions are not yet fully developed among the present young field hockey players who had, less than 5 years of training experience. Therefore, strength & conditioning programs need to be modified as they do not have positional differences in many of the body composition parameters relative and selected physiological parameters as well, and direct application of the program used by senior players may not be appropriate.

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