©Human Biology Review
www.humanbiologyjournal.com

Human Biology Review (ISSN 2277 4424) 2 (3) 2013
Original scientific paper (Koley and Yadav pp. 243-253)
Revised and Accepted on June 18, 2013

Assessment of Nutritional Status by Anthropometric Indices of Indian Elite Male Soccer Players

Shyamal Koley* and Anupkumar B. Yadav*

*Department of Sports Medicine and Physiotherapy, Guru Nanak Dev University, Amritsar - 143005, Punjab, India
Corresponding author: Dr. Shyamal Koley, Ph.D., Associate Professor and Head, Department of Sports Medicine and Physiotherapy, Guru Nanak Dev University, Amritsar-143005, Punjab, India E mail: drkoley@yahoo.co.uk

ABSTRACT: *The present study deals with the estimation of nutritional status by four anthropometric indices in purposely selected 60 Indian elite male soccer players (further divided as per their playing positions) aged 20–30 years (mean age 24.33 years ± 2.56) collected from Punjab Armed Police, Jalandhar, Punjab, India. A total of 60 controls were also collected from the same place for comparison. As many as eleven anthropometric traits, viz. height, weight, BMI, percent body fat, percent lean body mass, relative body weight, circumference of the upper arm during an isometric contraction and relaxed position of biceps brachii, circumference of thorax, circumference of abdomen and shoulder width were measured on all the subjects by standard techniques in pre-season. Four anthropometric indices, viz. Quetelet's index (QI), Oliver's typologic index (OTI), Lorenz's constitutional index (LCI) and muscle index (MI) were derived from those anthropometric traits. One way ANOVA was tested followed by post hoc Bonferroni test and Pearson's correlation coefficients were applied to analyze the data. In findings, the one way ANOVA showed statistically significant differences ($p < .001$) in all the variables studied, except LCI among these five sets of data. In all the anthropometric indices, soccer players with all the positions had significant differences ($p < .001$) with controls. It was also found that the nutritional status estimated by QI and OTI were closely associated with the Indian elite male soccer players, but not by MI and LCI. From the findings of the present study, it may be concluded that anthropometric indices would also be successfully used for the assessment of nutritional status of the soccer players.*

Keywords: *Quetelet's Index, Oliver's Typologic Index, Lorenz's Constitutional Index, Muscle Index.*

INTRODUCTION

Nutrition plays a very important role in attaining high level of achievements in sports (Kraider et al. 2009). Nutritional status has a direct bearing on the level of physical performance (Kerksick et al. 2008). Hence, physical fitness and training are very much dependent on nutritional status of sports personnel (Rodriguez et al. 2009). The soccer is an endurance sport and the endurance performance of the players was reported (Bangsbo and Lindquist 1992). Activity profiles of soccer players were studied by a number of researchers (Bangsbo and Lindquist 1993, Castagna and D"Ottavio 1999, Nicholas et al. 2000). Subsequently, fluid replacement is essential for

optimal performance and fatigue management (Shepard 1990, Hawley et al. 1994, Maughan and Leiper 1994, American College of Sports Medicine 1996, Sanz-Rico et al. 1996, McGregor et al. 1999, Casa et al. 2000, Murray 2000, Monteiro et al.2003) Carbohydrate supplements are usually provided to the soccer players before, during and after game (Foster et al. 1986, Leatt and Jacobs 1989, Smith et al. 1992, Hargreaves 1994. Nicholas et al. 1995, Shepard 1999, Ostojic and Mazic 2002). The importance of anthropometric characteristics and body composition on performance in soccer was also reported (Rico-Sanz 1998, Reilly et al. 2000, Rienzi et al. 2000, Reeves and Collins 2003, Iglesias-Gutiérrez et al. 2005).

The most widely studied method for the assessment of nutritional status in soccer players is BMI (Nekesa 2011). The American Heart Association's recommended guidelines following BMI values for the degree of nutrition are:

-BMI < 18.5 kg/m^2 indicates undernutrition

-BMI 18.5 – 24.9 kg/m^2 indicates normal values

-BMI 25.0 – 30.0 kg/m^2 indicates hypernutrition

-BMI 30.0 kg/m^2 indicates obesity

-BMI 40.0 kg/m^2 or more indicates extreme obesity.

Nutritional status could also be assessed by handgrip strength (Kaur and Koley 2010), as it is considered as the indicator of body strength (Foo 2007). Other anthropometric characteristics and indices are less reported for this purpose (Celan and Turk 2005). Though association of anthropometric indices with the incidence and duration of low back pain was reported earlier (Koley and Arora 2012a, 2012b) but no such study was reported related with football players. Thus the present study was planned with the objectives to estimate the nutritional status of Indian elite male soccer players by four anthropometric indices and to search any association between these indices and anthropometric variables studied. The hypothesis of the study was that the nutritional status estimated by anthropometric indices would have close association with the soccer players.

METHODS AND SUBJECTS

Subjects

The present cross-sectional study was based on purposely selected 60 Indian national level male soccer players aged 20–30 years (mean age 24.33 years ± 2.56) collected from Punjab Armed Police, Jalandhar, Punjab, India. The soccer players were further divided into four groups, viz. goalkeepers (n= 11),

defenders (n= 15), midfielders (n=16) and strikers (n=18). An adequate number of controls (n = 60, mean age 24.28 years, ± 2.64) with no particular playing background were also collected from the same place for comparison. The age of the subjects were recorded from the date of birth registered in their institute. A written consent was obtained from all the subjects. The data were collected under natural environmental conditions in morning (between 8 AM. to 12 noon). The study was approved by the local ethics committee.

Anthropometric measurements

Eleven anthropometric characteristics, viz. height (HT), weight (WT), BMI, percent body fat (%BF), percent lean body mass (%LBM), relative body weight (RBW), circumference of the upper arm during an isometric contraction of biceps brachii (CCB), circumference of the upper arm in relaxed position of muscle biceps brachii (CRB), circumference of thorax (CT), circumference of abdomen (CA), and shoulder width (SW) were measured on all the subjects using the standard techniques (Lohmann et al 1988) and were measured in triplicate with the median value used as the criterion. Four anthropometric indices, viz. Quetelet's index (QI), Oliver's typologic index (OTI), Lorenz's constitutional index (LCI) and muscle index (MI) were derived from those anthropometric characteristics.

The height was recorded using a stadiometer (Holtain Ltd., Crymych, Dyfed, UK) to the nearest 0.1 cm, and weight was measured by digital standing scales (Model DS-410, Seiko, Tokyo, Japan) to the nearest 0.1 kg. BMI was then calculated using the formula weight (kg)/height^2 (m)^2. %BF was calculated standard formula (Womersely and Durnin 1977). %LBM was calculated subtracting %BF from 100. The following body indices were calculated by standard formula (Celan and Turk 2005):

Quetelet's Index (Devenport-Kaup's adaptation)

Quetelet's index (QI) represents a measure of nutrition status. It is calculated according to the formula:

$QI = BW/BH^2$,

where BW means body weight (g) and BH body height (cm). People with normal nutritional status have QI values between 2.15 – 2.56.

Relative body weight

Relative body weight (RBW) is another possibility to describe a nutritional status and uses the following formula:

RBW = (ABW / IBW) X 100,

where ABW means measured body weight (kg) and IBW ideal body weight, formula is given below:

IBW = (BH – 100) – {(BH -150) / 4} + {(AY – 20) / 4},

where AY means age (yrs) and BH body height (cm). The values between 90-110 are representing normal nutritional status.

Muscle Index

Muscle index (MI) is an orientation method about someone's muscle development. It is calculated according to the formula:

MI = {(CCB – CRB) / CRB} X 100,

where CCB means circumference of the upper arm during an isometric contraction of muscle biceps brachii at 90^0 of elbow flexion (cm) and CRB circumference of the upper arm in relaxed position of muscle biceps brachii at 90^0 elbow flexion (cm). Values between 5 - 12 are normal, values under 5 represent obese subjects with weak muscle and values over 12 represent children with strong muscles.

Lorenz's Constitutional Index

Lorenz's Constitutional Index (LCI) gives information about body's components with a following formula:

LCI = CT – CA -14,

where CT means circumference of thorax (cm) and CA circumference of abdomen (cm). If a calculated value is a positive, then an increase in a body mass goes on the account of muscles and bone. On contrary, if it's a negative then the adipose tissue is responsible for an increased body mass.

Olivier's Typologic Index

Olivier's Typologic Index (OTI) represents quick orientation measure about body constitution. It is calculated as below:

OTI = (SW / BW) X 100,

where SW means shoulder width (cm) and BW body weight (kg). Values over 67 suggest asthenic constitution, values from 58 – 67 muscular constitution and values under 58 picnic constitution.

Statistical analysis

Standard descriptive statistics (mean ± standard deviation) were determined for directly measured and derived variables. One way ANOVA (analysis of variance) was tested for the comparison of data among Indian strikers, midfielders, defenders and goalkeepers, followed by post hoc Bonferroni test (in the case of significant differences). Pearson's correlation coefficients were applied to establish the relationships among the variables measured in Indian elite male soccer players and controls. The data was evaluated for normalcy in order to pursue parametric testing. Data was analyzed using SPSS (Statistical Package for Social Science) version 17.0. A 5% level of probability was used to indicate statistical significance.

RESULTS

The descriptive statistics of selected anthropometric variables and indices Indian elite male soccer players and controls is shown in table 1. Goalkeepers were the tallest and heaviest among the players. One way analysis of variance showed statistically significant differences ($p < .000$) in all the variables studied, except LCI among these five sets of data. In all the anthropometric indices, soccer players with all the positions had significant differences ($p< .000$) with controls. When comparisons were made among the Indian elite male soccer players with different playing positions, no significant differences were found in any case for the anthropometric indices.

Bivariate correlations of the anthropometric characteristics and indices were examined in Indian elite male soccer players and controls in table 2. The upper triangle correlations of the table showed for Indian elite male soccer players and the lower triangle correlations for controls.

QI has significantly positive correlations with all the variables studied, except CCB, CT, SW and OTI. MI has no significant correlations with any case. LCI has significantly positive correlations with WT, BMI, %BF, %LBM, CA, QI and RBW. Whereas, OTI has significantly positive correlations with HT, CCB, MI and LCI.

The distribution of chi-squire values of QI, RBW, MI, LCI and OTI in Indian elite male soccer players and controls are shown in Table 3. QI, RBW and OTI had statistically significant association ($\chi 2= 34.828$, 25.920 and 11.518 respectively) with the players, whereas MI and LCI had no significant association in this regard.

Table 1. Descriptive statistics of anthropometric variables in Indian elite male soccer players and controls

Parameters	Striker (n=18)		Mid fielder (n=16)		Defender (n=15)		Goalkeeper (n=11)		Control (n=60)			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F	Sig
HT	171.06	4.87	172.88	4.81	173.27	4.58	181.27	6.21	172.10	5.49	7.814	<0.001
WT	64.61	4.01	66.12	4.67	71.40	3.16	79.45	6.09	72.53	10.70	7.472	<0.001
BMI	22.08	0.96	22.16	1.86	23.79	0.62	24.16	0.60	24.46	3.74	172.657	<0.001
% BF	17.11	1.28	17.21	2.49	19.40	0.83	19.90	0.80	20.31	5.02	1500.975	<0.001
% LBM	82.79	1.28	82.79	2.49	80.60	0.83	80.10	0.80	79.69	5.02	40.668	<0.001
CCB	28.37	1.77	28.50	1.90	29.90	1.74	32.00	1.53	32.10	2.87	14.083	<0.001
CRB	26.36	1.69	26.34	1.83	26.37	1.80	29.73	1.61	29.34	3.03	10.868	<0.001
CT	89.89	3.61	90.53	4.18	95.80	4.43	99.50	6.09	95.01	7.26	6.356	<0.001
CA	81.47	4.11	80.75	6.22	86.93	4.50	89.09	6.74	84.97	7.97	1265.442	<0.001
SW	41.92	0.92	42.16	1.73	43.20	1.03	44.55	1.42	42.63	2.21	3032.762	<0.001
QI	2.21	0.10	2.21	0.19	2.38	0.62	2.40	0.60	2.41	0.39	98.297	<0.001
RBW	100.49	5.11	100.30	8.63	107.24	2.91	109.82	3.20	110.94	17.44	3982.480	<0.001
MI	7.58	1.83	8.37	2.57	12.96	2.82	7.90	1.80	9.60	2.81	546.566	<0.001
LCI	-5.58	1.72	-4.22	4.49	-5.13	1.71	-3.59	3.72	-3.96	3.53	1.191	0.321
OTI	63.53	6.76	63.99	4.96	60.52	2.19	56.22	3.37	59.86	8.00	6.953	<0.001

HT = Height, WT = Weight, BMI = Body mass index, %BF = Percent body fat; %LBM = Percent lean body mass, CCB = Circumference of the upper arm during an isometric contraction of biceps brachii; CRB = Circumference of the upper arm in relaxed position of muscle biceps brachii; CT = Circumference of thorax; CA = Circumference of abdomen; SW = Shoulder width, Quetelet's index = QI, RBW = Relative body weight, Muscle index = MI, LCI = Lorenz's constitutional index and OTI = Olivier's typologic index

DISCUSSION

The soccer is a widely popular endurance sport (Bangsbo and Lindquist 1992) which requires heavy physical activity (Bangsbo and Lindquist 1993, Castagna and D"Ottavio 1999, Nicholas et al. 2000). Thus nutritional status has a direct bearing on the level of physical performance in soccer players (Kerksick et al. 2008). The nature of soccer demands a balanced diet, rich in energy and carbohydrate and with adequate micro-nutrients to increase the dietary components in order to meet the energetic demands of competition and training. The nutritional status of soccer

Table 2. Correlation matrix of anthropometric variables and indices in Indian elite male soccer players and controls

	HT	WT	BMI	%BF	%LBM	CCB	CRB	CT	CA	SW	QI	RBW	MI	LCI	OTI
HT		0.425*	-0.438**	-0.438**	0.438**	-0.032	-0.081	0.254	0.155	0.162	-0.493**	-0.459**	0.091	0.054	-0.005
WT	0.943**		0.626**	0.626**	-0.626**	0.259	0.316	0.531**	0.667**	0.221	0.558**	0.578**	-0.228	-0.416*	-0.468**
BMI	0.056	0.385		0.982**	0.984**	0.384*	0.287	0.304	0.531**	0.093	0.976**	0.965**	-0.292	-0.468**	-0.449**
%BF	0.056	0.385	0.979**		-0.976**	0.287	0.384*	0.304	0.531**	0.093	0.976**	0.965**	-0.292	-0.468**	-0.449**
%LBM	-0.056	-0.385	-0.982**	-0.975**		-0.287	-0.384*	-0.304	-0.531**	-0.093	-0.976**	-0.965**	0.292	0.468**	0.449**
CCB	0.365	0.439*	0.283	0.283	-0.283		0.952**	0.433*	0.414*	-0.058	0.256	0.284	-0.005	-0.139	-0.331
CRB	0.437*	0.525**	0.342	0.342	-0.342	0.958**		0.383*	0.455**	-0.018	0.363*	0.381*	-0.297	-0.261	-0.369*
CT	0.694**	0.727**	0.251	0.251	-0.251	0.215	0.278		.760**	0.108	0.247	0.283	0.025	-0.019	-0.379*
CA	0.556**	0.528**	0.044	0.044	-0.044	0.186	0.229	0.870**		0.265	0.458**	0.488**	-0.188	-0.664**	-0.360*
SW	0.631**	0.773**	0.581**	0.581**	-0.581**	0.343	0.428*	0.693**	0.584**		0.066	0.033	0.065	-0.283	.348*
QI	0.049	0.379	0.973**	0.986**	-0.955**	0.287	0.347	0.247	0.042	0.574**		0.988**	-0.327	-0.421*	-0.407*
RBW	0.215	0.513**	0.940**	0.940**	-0.940**	0.302	0.365	0.321	0.101	0.690**	0.936**		-0.31	-0.425*	-0.406*
MI	-0.345	-0.459*	-0.413*	-0.413*	0.413*	-0.604**	-0.736**	-0.375	-0.334	-0.541**	-0.412*	-0.403*		0.318	0.244
LCI	0.241	0.36	0.398*	0.398*	-0.398*	0.049	0.084	0.211	-0.299	0.182	0.395*	.421*	-0.064		0.117
OTI	-0.945**	-0.942**	-0.204	-0.204	0.204	-0.38	-0.452*	-0.623**	-0.414*	-0.521**	-0.199	-0.32	0.322	-0.386	

Upper triangle: correlations for male players and lower triangle: correlations for controls;
* Significant at .05 level (2-tailed); ** Significant for .01 level (2-tailed)

players were assessed by BMI and 24 hour recall method (Nekesa 2011). Assessment of nutritional status by anthropometric indices in soccer players remains largely unreported. Thus, the objectives of the present study were fully justified.

Table 3. Distribution of anthropometric indices in Indian elite male soccer players and controls

Anthropometric Indices	Categories	Male soccer players		Controls		$\chi 2$
		Abs. No	%age	Abs. No	%age	
QI	Normal values	54	90.00	23	38.33	34.828**
	Abnormal values	06	10.00	37	61.67	
RBW	Normal values	51	85.00	24	40.00	25.92**
	Abnormal values	09	15.00	36	60.00	
LQI	Positive values	04	06.67	09	15.00	2.156
	Negative values	56	93.33	51	85.00	
MI	< 5	-		05	08.33	
	5 - 12	51	85.00	47	78.34	5.222
	12 >	09	15.00	06	13.33	
OTI	< 58	11	18.33	26	43.33	
	58 - 67	42	70.00	24	40.00	11.518*
	67 >	07	11.67	10	16.67	

* Significant at 0.01 level (2-tailed), ** Significant at 0.001 level (2-tailed).

The findings of the present study indicated statistically significant differences ($p < .000$) in all the anthropometric variables and indices studied between soccer players with all the positions and controls. These differences were due to regular strenuous exercise and training effects of the soccer players. When playing position-wise comparisons were made among the Indian elite male soccer players, no significant differences were found in any case for the anthropometric indices. It indicated that no special diet was provided to the players as per their playing positions. When an attempt was made to search any association of these anthropometric indices with the nutritional status of the players, it was found that, for QI, 90% players fall well within the range of normal nutritional status (2.15 – 2.56), whereas 61.67% controls had the abnormal values, showing close significant associations of the trait with the nutritional status of the players. For OTI, 70% players were found to be of muscular constitution (58-67), 18.33% picnic and 11.67% asthenic, whereas, 40.00% controls had the muscular constitution, 43.37% picnic and 16.67% asthenic, highlighting close association with this trait and the nutritional status of the players. In case of MI and LCI, no significant association was found. The findings of the present study were not compared with other athletes due to lack of reported data as the study was the first of its kind. The data presented in the present study carry immense practical application and may be useful in planning of dietary regime of the soccer players adjusted with training program.

CONCLUSIONS

From the findings of the present study, it may be concluded that, though BMI is widely used for the assessment of nutritional status, anthropometric indices may also be successfully used for this purpose in the light of nutritional status and muscle development. Future researches are required considering larger sample size with both male and female soccer players to validate the findings.

Conflict of interest: None.

ACKNOWLEDGEMENTS

Authors are thankful to the authorities of Punjab Armed Police, Jalandhar, Punjab, India and the participant soccer players of the institute for their cooperation in collecting the data.

REFERENCES

American College of Sports Medicine 1996. Position Stand on Exercise and Fluid Replacement. *Medicine and Science in Sports and Exercise* **228**: i-vii.

Bangsbo J, Lindquist B. 1993. Applied physiology of soccer. *Sports Medicine* **3**: 50-60.

Bangsbo J, Lindquist F. 1992.Comparison of various exercise tests with endurance performance during soccer in professional players. *International Journal of Sports Medicine* **113**: 125-132.

Casa DJ, Armstrong LA, Hilliman SK, et al. 2000. National Athletic Trainers' Association Position Statement: Fluid replacement for athletes. *Journal of Athletic Traininig* **335**: 212-224.
Castagna C, D"Ottavio S. 1999. Activity profile of elite soccer referees during competitive matches. *Journal of Sports Science* 117: 825.

Celan D, Turk Z. 2005. The inpact of anthropometric parameters on the incidence of low back pain. *Coll Anthropol* **29(1)**: 101-105.

Foo LH. 2007. Influence of body composition, muscle strength, diet and physical activity on total body and forearm bone mass in Chinese adolescent girls**.** *British Journal of Nutrition* **98**: 1281-1267.

Foster C, Thompson NN, Dean J, et al. 1986. Carbohydrate supplementation and performance in soccer payers. *Medicine Science Sports Exercise* **118**: S12.

Hargreaves M. 1994. Carbohydrate and lipid requirements of soccer. *Journal of Sports Sciences* **12**: S13-S16.

Hawley J, Dennis S, Noakes T. 1994. Carbohydrate, fluid and electrolyte requirements of the soccer players: a review. *IInternational Journal of Sport Nutrition* **44**: 221-236.

Iglesias-Gutiérrez E, García-Rovés PM, Rodríguez C, et al. 2005. Food Habits and Nutritional Status Assessment of Adolescent Soccer Players. A Necessary and Accurate Approach. *Canadian Journal of Applied Physiology* **30(1)**: 18-32.

Kaur N, Koley S. 2010. An association of nutritional status and hand grip strength in female laborers and sedentary women of Jalandhar, Punjab, India. *The Anthropologist* **12(4)**: 237-243.

Kerksick C, Harvey T, Stout J, et al. 2008. International Society of Sports Nutrition position stand: nutrient timing. *J Int Soc Sports Nutr* **5**:17.

Koley S, Arora H. 2012a. Association of anthropometric indices with duration of low back pain. *The Anthropologist* **14(5)**: 453-458.

Koley S, Arora H. 2012b. Impact of anthropometric indices on the incidence of low back pain. *Ibnosina Journal of Medicine and Biomedical Sciences* **4(4)**: 115-121.

Kreider R, Leutholtz B, Katch F, Katch V. 2009. *Exercise & Sport Nutrition.* Santa Barbara: Fitness Technologies Press.

Leatt PB, Jacobs I. 1989. Effect of glucose polymer ingestion on glycogen depletion during a soccer match. *Canadian Journal of Sports Science* **14**: 112-116.

Lohmann TG, Roche AF, Martorell R. 1988. *.Anthropometric Standardization Reference Manual.* Champaign, IL: Human Kinetics Books.

Maughan RJ, Leiper JB. 1994. Fluid replacement requirements in soccer. *Journal of Sports Sciences* **112**: S29-S34.

McGregor SJ, Nicholas CW, Lakomy HKA, et al. 1999. The influence of intermittent high-intensity shuttle running and fluid ingestion on the performance of a soccer skill. *Journal of Sports Science* **117**: 895-903.

Monteiro CR, Guerra I, Barros T. 2003. Hidratação no futebol: uma revisão. *Revista Brasileira de Medicina do Esporte* **99**: 238-242 (In Portuguese: English abstract).

Murray R. 2000. Fluid and electrolytes. In: *A guide for the professional working with active people.* Ed: Rosenbloom, C.A. 3rd edition. Chicago, pp. 95-106.

Nekesa, SW. 2011. *Nutritional status and protein dietary intake of soccer players in the premiuer league, Nairobi Province.* Master thesis, Kenyatta University Institution Repository, Nigria.

Nicholas CW, Nuttal FE, Williams C. 2000. The Loughborough Intermittent Shuttle Test : A field test that simulates the activity pattern of soccer. *Journal of Sports Sciences* **118**: 97-104.

Nicholas CW, Williams C, Lakomy HK, et al. 1995. Influence of ingesting a carbohydrate-electrolyte solution on endurance capacity during intermittent, high-intensity shuttle running. *Journal of Sports Sciences* **13**: 283-290.

Ostojic SM, Mazic S. 2002. Effects of a carbohydrate-electrolyte drink on specific soccer tests and performance. *Journal of Sports Science and Medicine* **1**: 47-53.

Reeves S, Collins K. 2003. The nutritional and anthropometric status of Gaelic football players. *Int J Sport Nutr Exerc Metab* **13(4)**: 539-548.

Reilly T, Bangsbo J, Franks A. 2000. Anthropometric and physiological predispositions for elite soccer. *Journal of Sports Sciences* **118**: 669-683.

Rico-Sanz J. 1998. Body composition and nutritional assessments in soccer. *International Journal of Sport Nutrition* **8**: 113–123.

Rienzi E, Drust B, Reilly T, et al. 2000. Investigation of anthropometric and work-rate profiles of elite South American international soccer players. *Journal of Sports Medicine and Physical Fitness* **40**: 162-169.

Rodriguez NR, Di Marco NM, Langley S. 2009. American College of Sports Medicine position stand. Nutrition and athletic performance. *Med Sci Sports Exerc* **41(3)**: 709–731.

Sanz-Rico J, Frontera WR, Rivera MA, et al. 1996. Effects of hyperhydration on total body water, temperature regulation and performance of elite young soccer players in a warm climate. *International Journal Sports Medicine* **17**: 85-91.

Shepard RJ. 1999. Biology and medicine of soccer : an update. *Journal Sports Science* **17**: 757-786.

Shepard RJ. 1990. Meeting carbohydrate and fluids needs in soccer. *Canadian Journal Sports Science* **15**: 165-171.

Smith K, Smith N, Wishart C, et al. 1992. Effect of a carbohydrate-electrolyte solution on fatigue during a soccer-related running test. *Journal of Sports Science* **119**: 502-503.

Womersely J, Durnin JUGA. 1977. A Comparison of the skinfold method with extent of of "overweight" and various weight height relationship in the assessment of *Obesity Br J Nutr* **38**: 271-284.

Citation: Koley S and Yadav AB. 2013. Assessment of Nutritional Status by Anthropometric Indices of Indian Elite Male Soccer Players. Hum Bio Rev, 2 (3), 243-253.