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Assessment of body cell mass in Indian junior elite players (male) of different sports using bioelectrical impedance analysis method

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Abstract. The aim of this study was to assess and evaluate Body Cell Mass (BCM) of Indian junior male players of different sports discipline using Bio-electrical Impedance Analysis (BIA). *Material and Method*. 79 male subjects (age range =14-20 years) were participated in the present study from various sports discipline, football (N=15), gymnastics (N=15), hockey (N=16), table tennis (N=15) and age-matched sedentary control group (N=18). Whole body bioelectrical impedance analysis was performed using a multi-frequency analyzer (Maltron Bioscan 920-2, Maltron International, Rayleigh, Essex, UK). Physical characteristics, fat and fat free mass, protein, muscle and glycogen mass along with body cell mass (BCM) were evaluated. *Results.* Significant ($p<0.01$) differences were observed in height, weight and BMI except mean age of the subjects of different sports discipline and control group when compared among the groups. Body composition parameters except adiposity were found to be higher in hockey players as compared to their other counterparts. On the other hand, gymnasts were found to be smaller in size & have lower values in all the selected parameters. Significant differences ($p<0.05$ and $p<0.01$) were also observed in all the parameters when gymnasts were compared with the table tennis players. BCM in respect to body weight (relative BCM %) was found to be lower in table tennis players and higher in case of hockey players respectively. BCM was found to be highly correlated ($P<0.01$) with fat free mass and body weight in all the groups. *Conclusion.* BCM is related to the ability to extract and utilise oxygen by the working muscles and also to the improvement of muscular efficiency during activity. The present findings will be useful for the trainer to formulate the systematic and scientific training program to enhance sport performance as well as for future comparison.
Key words: *body cell mass, bioelectrical impedance analysis, football, hockey, gymnastics, table tennis*.

Introduction

Body composition has a significant effect on athletic performance as exercise has the potential to alter body composition (1). For the assessment of body composition, recently a new approach has been regarded most meaningful is to measure the body cell mass (BCM) apart from simply assessing fat free mass and fat mass (2). BCM is defined as the total mass of "oxygen-consuming, carbon-dioxide producing, potassium-enriched, glucose oxidizing and metabolically active, work performing" cells of the body. BCM comprises protein-rich intracellular tissues responsible for nearly all of the metabolic process in the body and also for strength (3). In a normal healthy individual, muscle tissue consists approximately 60% of the body cell mass. The volume and function of the muscle portions of BCM further can be enhanced by physical activity and systematic exercise. Therefore, the evaluation of body cell mass in athletes is a stronger predictor of athletic performance and strength (2).

The "gold standard" method for the assessment of the BCM is by the means of naturally occurring isotope ^{40}K and NaBr dilution. Precise estimates of BCM can also be obtained by the measurement of the difference between extracellular water (ECW) and total body water (TBW) using multiple isotopes or the total-body potassium (^{42}K) approach. However, all these methods are found to be expensive, time consuming and not generally applicable in the field studies. Bioelectrical Impedance Analysis (BIA), in contrast, is relatively simple, quick (takes only a few minutes), and non-invasive technique by which BCM can be simply measured after injecting a standard current at a known frequency. BIA uses prediction equations usually include the impedance index ($height^2$/resistance) which is dependent on the capacitance effect of cell membranes and tissue interfaces (4). Football, hockey, table tennis and gymnastics are of four different sports among which football and hockey

although have its own distinctive skills, tactics and movement patterns, but they have almost similar physiological demands such as high aerobic power, high lactate tolerance and increased anaerobic capacity (5). On the other hand, gymnastics is a type of strength-power sport, demanding high levels of both flexibility and anaerobic capacities for successful performance (6). While Mitchell et al (7) classified sports activities based on the static component, dynamic component and energy system involved, where table tennis falls into the low-moderate group of sports, together with baseball, softball, volleyball and tennis (doubles) etc. Therefore, the amount of aerobic and anaerobic components varies among these sports. Thus, evaluating and comparing the body cell mass of these different athletes would provide new insight into the field of body composition.

As per literature, very scanty research has been conducted in professional athletes worldwide. However, in recent years few studies (2, 8-9) have been conducted to verify the impact of different sports in body cell mass (BCM). In spite of the availability of the literature related to the assessment of the impact of different sports in body cell mass (BCM), standard data on such parameters are scanty in Indian context. To fulfill the lacunae of literature, the present study was undertaken i) to assess and evaluate BCM and related parameters of Indian junior elite male players and ii) to compare BCM and related parameters among the players of different sports disciplines.

Material and method

The present study was carried out on 61 male junior elite athletes of football (N=15; mean age= 15.2±0.86 years), gymnastics (N=15; mean age= 15.3±2.92 years), hockey (N=16; mean age= 15.4±0.78 years) and table tennis (N=15; mean age= 15.6±2.27 years). An adequate number of age- matched male control group (N=18; mean age= 15.4±0.55 years) with no particular athletic background from the same place was also included in the study. All the players were belonging to 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 formal training history. All the subjects including the control group were evaluated for various anthropometric and physiological variables at Human Performance Laboratory of Sports Authority of India, Kolkata. The players were belonged to almost same socio-economic status with similar dietary habits and got trained in same kind of environmental/climatic condition. Hence, they were considered as homogeneous.

Before the commencement of test all the subjects were clinically examined by the physicians of SAI, Kolkata, who are specialized in Sports Medicine following standard procedure (10). 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. The subjects who were found to be medically fit, healthy and with no history of any hereditary and cardio respiratory diseases, were finally selected for the present study.

Training program. The formulation and implementation of systematic training program was made by the qualified coaches with the guidance of the scientific expert from Sport Science Department, SAI, Kolkata. The training regimen was almost common to all the four games of the present study except the skill training and was used to apply on an average 4 to 5 hours every day except Sunday and which comes about 30 hours in a week. There were two sessions in a day i. e. morning session and evening session and both of which comprised of physical training for one hour and skill training for about two hours.

The physical training schedule includes different strength and endurance training program along with flexibility exercises. Strength and Endurance training was also applied according to their sports specific requirement. Warm up and cool down sessions after and before starting of 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.

On the other hand, control group's activity levels were not closely monitored. However, these subjects did not exercise more than three times per week, for a total of approximately 3 hours in a week. Physical activities consisted of running, jogging, recreational games, etc.

Measurement procedure. The physical characteristics of the subjects including height (cm) and weight (kg) were measured by anthropometric rod and digital weighing machine respectively followed by standard procedure (11). The decimal age of all the subjects were calculated from their date of birth recorded from

original birth certificate, produced by them at the time of testing.

*Bioelectrical Impedance Analysis (BIA).*Body composition including body cell mass (BCM), body mass index (BMI), fat free mass (FFM), fat mass, total fat percent, total muscle mass (TMM), protein mass, glycogen mass and relative BCM were measured using Bioelectrical Impedance Analysis (BIA) with a multi-frequency analyzer (Maltron Bioscan 920-2, Made in UK). Total body electrical impedance to an alternate current (0.8 mA) with four different frequencies (5, 50, 100 and 200 KHz) was measured. Measurements were taken followed by the standard testing manual of Maltron International (12). The subject was in a supine position taking rest for 5 minutes on a non-conducting surface, with the arms slightly abducted from the trunk and the legs slightly separated. Before placing the surface electrodes, the sites were cleaned using isopropyl alcohol ensuring adherence and to limit the possible errors. Surface electrodes were placed on the right side of the body on the dorsal surface of the hands and feet. In case of hand, electrodes were placed proximal to the metacarpal-phalangeal and medially between the distal prominences of the radius and ulna. In case of feet, electrodes were placed proximal to the metatarsal-phalangeal joints, respectively, and also medially between the medial and lateral malleoli at the ankle. Before testing, the analyzer was calibrated according to the manufacturer's instructions. Before taking the measurement, the players were instructed according to Heyward & Stolarczyk (13) by the following guidelines: 1) no heavy exercise 12 h before the test; 2) no large meals 4 h before the test; and 3) consumption of liquids limited to 1% of body weight, or, two 8-oz. glasses of water, 2 h before the test. FFM and BCM were calculated using the formula developed by Bhat et al (14), De Lorenzo et al (4) respectively. All the tests were conducted at a room temperature varying from 23 to 25 degree centigrade with relative humidity varying between 50- 60%.

Statistical Analysis. Differences among groups for all variables according to their specific sport disciplines were calculated using a one-way analysis of variance (ANOVA). If significant main effects or interactions occurred, Scheffe's post-hoc multiple comparison test was used to detect the differences among the selected parameters of the four sport disciplines and control group. The data were analyzed using the Statistical Program for the Social Sciences (SPSS) version 21.0 for Windows (SPSS Inc., Chicago, Il, USA). All values are expressed as means ± standard deviation (SD). A confidence level at 5% ($p<0.05$) was considered as significant. Correlation coefficient between BCM and other parameters were also represented graphically to make comparison among male athletes of different sport disciplines and male control group.

Results

Table I represents the physical characteristics of the subjects according to their specific groups. Table tennis players were found to be bigger in size whereas gymnasts exhibit smaller in size as compared to all the sport disciplines and control group. On the other hand height was dominated by the hockey players (167.6 cm, ±4.43) and found to be tallest in respect to their other counterparts. Significant difference ($p<0.01$) in height, weight and BMI was observed when compared among the groups. No such significant difference was observed in age.

Table I. Mean, standard deviation and level of significance of General Physical Characteristics of all subjects

Variables	Football (N=15)	Gymnastics (N=15)	Hockey (N=16)	Table Tennis (N=15)	Control (N=18)	Level of Significance
Decimal Age (yrs)	15.2 ±0.86	15.3 ±2.92	15.4 ±0.78	15.6 ±2.27	15.4 ±0.55	NS
Height(cm)	164.3 ±3.76	153.3 ±9.97	167.6 ±4.43	165.5 ±5.68	163.4 ±2.73	**
Weight(kg)	51.4 ±2.80	43.0 ±10.01	56.1 ±4.58	59.1 ±10.47	51.6 ±6.23	**
BMI ($kg.m^{-2}$)	19.1 ±1.24	18.0 ±2.25	20.3 ±1.66	21.4 ±3.03	19.3 ±2.51	**

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

Table II represents all the body composition parameters of the subjects according to the specific groups. Again table tennis players' exhibited high adiposity as compared to rest of the groups whereas gymnasts possess comparatively lowest body fat. The table further reveals that hockey players found to have higher values in the body composition parameters (fat free mass, body cell mass, glycogen mass) comparatively to all the sport disciplines and control group. Gymnasts followed by the control group showed lowest values in case of all theses parameters. BCM in respect to body weight (Relative BCM%) was found to be lower in table tennis players and higher in case of hockey players respectively. A statistically significant difference ($p<0.01$) was observed in case of all the parameters when compared among the groups. Scheffe's F test for multiple comparisons of the selected parameters among the groups was represented by Table III.

Table II. Mean, standard deviation and level of significance of Body composition of all subjects

Variables	Football (N=15)	Gymnastics (N=15)	Hockey (N=16)	Table Tennis (N=15)	Control (N=18)	Level of Significance
Fat Mass (kg)	8.6 ±2.41	4.8 ±1.21	7.3 ±2.25	11.1 ±6.99	9.2 ±3.81	**
Body Fat (%)	16.8 ±4.56	11.6 ±3.06	12.8 ±4.01	18.1 ±8.61	17.6 ±6.13	**
Fat Free Mass (kg)	42.7 ±3.24	38.1 ±9.51	49.9 ±4.65	48.0 ±7.39	42.4 ±5.23	**
Body Cell Mass (kg)	23.8 ±1.44	20.4 ±5.17	27.0 ±2.02	26.4 ±3.94	23.5 ±2.49	**
Protein Mass (kg)	8.8 ±0.79	7.7 ±1.98	10.6 ±1.14	9.8 ±2.31	8.7 ±1.52	**
Muscle Mass (kg)	21.1 ±1.37	18.2 ±4.87	24.2 ±2.04	23.5 ±3.77	20.8 ±2.40	**
Glycogen Mass (gm)	388.0 ±29.52	346.3 ±86.42	452.8 ±42.16	436.1 ±67.12	384.7 ±47.55	**
Relative BCM (%)	46.4 ±1.19	47.3 ±1.71	48.1 ±1.91	44.9 ±2.48	45.8 ±1.70	**

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

Table III. Scheffe's F test for multiple comparisons of physical characteristics and body composition

Variables	FB vs GYM	FB vs HK	FB vs TT	FB vs CTRL	GYM vs HK	GYM vs TT	GYM vs CTRL	HK vs TT	HK vs CTRL	TT vs CTRL
Height (cm)	**	NS	NS	NS	**	**	**	NS	NS	NS
Weight (Kg)	NS	NS	NS	NS	**	**	**	NS	NS	NS
Body Mass Index ($kg.m^{-2}$)	NS	NS	NS	NS	NS	**	NS	NS	NS	NS
Fat Mass (Kg)	NS	NS	NS	NS	NS	**	*	NS	NS	NS
Body Fat (%)	NS	NS	NS	NS	NS	*	NS	NS	NS	NS
Fat Free Mass (kg)	NS	NS	NS	NS	**	**	NS	NS	*	NS
Body Cell Mass (kg)	NS	NS	NS	NS	**	**	NS	NS	NS	NS
Protein Mass (kg)	NS	NS	NS	NS	**	*	NS	NS	*	NS
Muscle Mass (kg)	NS	NS	NS	NS	**	**	NS	NS	*	NS
Glycogen Mass (gm)	NS	NS	NS	NS	**	**	NS	NS	*	NS
Relative BCM (%)	NS	NS	NS	NS	NS	*	NS	**	*	NS

*vs=versus; Values are (mean ± sd); **P< 0.01,* P< 0.05, NS= Not Significant. FB= Football; GYM= Gymnastics; HK= Hockey; TT= Table Tennis; CTRL=Control*