



Comparison of Anthropometric Characteristics, Body Composition Profile and Physical Fitness Parameters of Indian National Women Rugby Players According to Their Specific Playing Position

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Received 2019 January 07; Accepted 2019 January 21.

Abstract

Background: Scientific researches available on anthropometric and physiological characteristics of female rugby players in India are very scanty.

Objectives: The present study was aimed to evaluate and compare different anthropometric, body composition and physical fitness parameters and also to investigate whether any distinctive characteristics exist among above variables according to their specific playing position.

Methods: Twenty five Indian national women rugby players (forward, n = 12, mean age = 20.9 ± 3.30 and back, n = 13, mean age = 19.7 ± 2.48) of pre-competitive phase were chosen as subject from the national coaching camp. They were evaluated for various anthropometric, body composition parameters, hemoglobin, blood glucose level and physical fitness profile by following standard procedure.

Results: Forward players had significantly higher body weight, BMI, fat percentage, sum of skinfold, total body potassium, total body calcium and glycogen content as compared to the back. Whereas, players of back position had significantly higher relative muscle mass (MM/Wt.), relative body cell mass (BCM/Wt.), agility, standing broad jump, VO₂max and relative peak anaerobic power than their forward counterparts. Linear regression model identified agility ($\beta = 0.59$) and sum of skinfold ($\beta = -0.45$) as significant predictor of peak anaerobic power (adjusted R² = 0.61) of these players.

Conclusions: Present study indicated the players of back position were faster, more agile and aerobically fit with having lower body weight and fat percent as compared to their forward counterparts. Whereas, principal component analysis identified BMI, sum of skinfold and agility as the main confounding variables to categorize the present rugby players between forward and back positional groups.

Keywords: Agility, Sum of Skinfold, Leg Explosive Power, Relative Peak Anaerobic Power, VO₂max

1. Background

Rugby is a body contact game which needs precise skills for actions like kicking, passing, tackling, breaking tackles, cruising, sprinting etc. (1, 2). Physiological demands need to improve with muscular strength, speed ability, agility, and endurance capacity etc. to optimize the performance. The movement pattern reflects the short bout high intensity game which followed by incomplete recovery periods (3, 4).

Reilly (5) and Nicholas (6) has stated that positional role has unique demands and less homogeneity among the individuals in different positions of rugby. Motion study by Meir et al. (7) and Gissane et al. (8) have showed that the playing position had difference in match play activi-

ties where backwards involved in significantly less physical collisions and tackles than forwards. Meir et al. (7, 9) have reported that the ratio of high to low intensity activity is was higher among forwards in comparison to the backwards, where it was also stated that forwards covered greater distance during a complete match than backwards (9929 m/8458 m) respectively.

Several studies have reported the significant difference in body mass, skin fold, speed ability, VO₂max, sprinting ability of rugby players in spite of their formal training age (9-11). Although the above studies were mainly done on American or European men rugby players and not clearly highlighted the importance of positional demand against every aspect. Literature further revealed that researches conducted on positional differences among the female

players are also scanty. No such study was reported so far on young women rugby players in India.

2. Objectives

The present study was undertaken to (I) evaluate and compare the different anthropometric, body composition and physical fitness parameters of young Indian national women rugby players and also whether the playing position have any role on the above parameters; (II) establish the relation between anthropometric and body composition variables with physiological parameters and also to identify the possible predictor for optimizing the performance.

3. Methods

3.1. Subjects

The present study was carried out on Indian female rugby players who were attending a national coaching camp at sports authority of India (SAI), Kolkata. The players were divided into two groups as per their playing positions i.e. forward ($n=12$; mean age = 20.9 ± 3.30 years; 8 prop and 4 hooker) and back ($n=13$; mean age = 19.7 ± 2.48 years; 4 winger, 4 scrum half, 3 fly half and 2 center). All the players were having minimum 5 years of formal training history. Before commencement of the test, they were clinically examined and only the medically fit players were chosen as subject for the present study. The present study followed the ethical guideline of Declaration of Helsinki (1975) and an informed consent was obtained from every players.

3.2. Training Regimen

A systematic training programme was formulated and implemented by the qualified coaches under the guidance of scientific experts. The Subjects were trained for two sessions daily (morning and evening) which comprises 4 - 5 hours of training altogether. Physical training was scheduled as per the demand of the game which includes strength, endurance, speed and flexibility training etc. Along with the physical training, specific skill training also included in the daily training schedule. Warm up and cool down session was done at the beginning and end of every training session respectively.

3.3. Anthropometric Measurement

Standing height (cm) was recorded to the nearest 0.1 cm by using a Seca stadiometer (model - 213, Seca Deutschland, Germany) and body weight (kg) was measured to the nearest 0.1 kg by using calibrated Seca alpha weighing scales (model 770) followed by the standard procedure.

Skinfold thicknesses were recorded by Harpenden skinfold calliper (British Indicators, UK) at the site of biceps, triceps, sub scapular and supra iliac (12). Both right and left handgrip strength (kg), relative back strength and trunk flexibility (cm) were measured with the help of handgrip and back dynamometer (Takei A5401, Takei Scientific Instruments Co., Ltd., Niigata City, Japan), and 'Sit-and-Reach flexometer' (Lafayette Instrumental Co., USA) followed by the standard procedure respectively (13).

3.4. Measurement of Body Composition Parameters

Body composition was analyzed by using multi-frequency bioelectrical impedance analyzer (MF-BIA) (Maltron International Ltd., Rayleigh, UK). muscle mass (MM), body cell mass (BCM), total body water (TBW), extra cellular water (ECW), intra cellular water (ICW), total body potassium (TBK), total body calcium (TBCa), minerals and glycogen content were assessed for all the players. MF-BIA was used in four different frequencies (5, 50, 100 and 200 KHz) against an alternate current of 0.2 mA to create the total body electrical impedance and the measurements were recorded followed by the standard testing manual of Maltron International (Maltron Bioscan 920 - II, operating system and service manual) (14).

3.5. Measurement of VO_2 max and Anaerobic Power

A modified 20 m multistage physical fitness test was conducted to measure the maximal oxygen uptake capacity (VO_2 max mL/kg/min). Players were maintained the running speed over the 20 m distance with the increasing frequency of 'beep' sound. The final estimation of VO_2 max was obtained from the shuttle/level scores by using a standard chart of Beep test (15). Anaerobic power output was measured by using running based anaerobic sprint test (RAST) protocol. Six consecutive sprints were done with maximum acceleration and 10 sec interval after each sprint. Each sprint time was recorded by using the Brower timing gate system (Brower Timing Systems, USA). Detailed procedure for both the tests was followed as per Draper and Whyte (16).

3.6. Measurement of Motor Ability Variables

Illinois agility test, 30 m flying start and standing board jump (SBJ) were conducted to measure agility, speed ability and explosive power of lower limbs respectively. Time was recorded using stopwatch to the nearest 0.01 second for agility test. Each player was given two attempts with a minimum rest of 4 minutes and the fastest time was recorded (17). Thirty m flying start was done to assess the speed ability of these athletes. Davis (18) standard procedure was followed to accomplish 30 m flying start.

Each sprint time was recorded by using the Brower timing gate system (Brower Timing Systems, USA). Standing board jump (SBJ) was conducted followed by AAHPER to measure the explosive power of lower limbs of athletes (19).

3.7. Measurement of Hemoglobin

Beckman Coulter Gen S system (Beckman Coulter Inc., Fullerton, CA, USA) was used for determining the blood hemoglobin (Hb%) level (20).

3.8. Statistical Analysis

Analysis of data was done by using SPSS version 16.0 for Windows (SPSS Inc., Chicago, IL, USA). All recorded values were expressed as means \pm standard deviation (SD) and the normality. Assumption of normality was verified using the Shapiro-Wilk W-test. Difference between mean of positional groups for all variables were done by independent t-test. Linear regression and scatter plots were done at level of significance $P \leq 0.05$. Principle component analysis was done to identify the predictor variables for differentiating between the groups as per their specific playing position.

4. Results

Table 1 demonstrated the comparison of mean, standard deviation and level of significance of various anthropometric parameters and body composition profile of Indian female rugby players at two different playing positions. It was evident from the table that body weight, body mass index (BMI), fat mass percentage (FM%), sum of skinfold, body cell mass (BCM), muscle mass (MM), total body potassium content (TBK), total body calcium content (TBCa) and glycogen content were significantly higher in forwards and fat free mass percentage (FFM%), relative BCM and relative MM were found to be significantly higher among the players of back position when compared between the groups. All other parameters were not differed significantly after the comparison.

Table 2 depicts mean, standard deviation and level of significance of various motor ability variables of Indian women rugby players of two different playing positions. The table showed that agility, SBJ, VO_2 max and relative peak anaerobic power (R power) were found to be significantly ($P < 0.05$) higher among backwards than forwards. But no such significant differences were observed in other motor and strength variables.

Table 3 depicted the coefficient of correlation between some selected body composition parameters with physical fitness variables of present rugby players (combining together the back and forward group). A significant positive correlation was observed between sum of skinfold and

weight ($P < 0.01$), BMI and 30 m flying start ($P < 0.05$) where as VO_2 max and R power was found to be significantly ($P < 0.01$) and negatively correlated with the sum of skin fold thickness. Both MM and BCM were negatively and significantly correlated with weight and BMI but positively and significantly related with RBS ($P < 0.05$) and VO_2 max ($P < 0.01$). On the other hand BCM and MM was negatively and significantly ($P < 0.01$) related with sum of skinfold.

Table 4 demonstrated the prediction of regression coefficient of relative peak power from linear regression model. Agility ($P < 0.001$) and sum of skinfold ($P < 0.01$) both were found to be the significant predictor ($R^2 = 0.644$, Adj $R^2 = 0.612$, $F = 19.92$, Sig. = 0.000) for the relative peak power among which agility was positively and sum of skinfold was negatively correlated with the dependent variable.

Table 5 depicted the descriptive statistics of principle component analysis of various anthropometric and physical fitness parameters of Indian national women rugby players. BMI was found to be the main predictor with percentage variance of $> 50\%$ and Eigen value of 3.17 among the women rugby players. However, sum of skinfold and agility was also identified as the important predictor with percentage variance of $> 10\%$ to classify the players among positional groups.

5. Discussion

As shown in the results, Forwards of the present study were heavier, taller and have a greater proportion of body fat along with sum of skinfold than backwards. Almost similar findings were also observed by Gabbett (21) and Durandt et al. (22) and have concluded a protective role of high skinfold thickness and FM% against the physical collisions as body fat aids in absorbing impact during tackles and collision sustained by forwards. Zyla et al. (23) have also reported that the heavier body mass of forwards help them to generate a higher momentum to break through tackles from opponents.

Both relative BCM and MM were found to be significantly higher among the backwards than forwards and corroborated with the findings of Durandt et al. (22) where they have indicated the rate of muscular hypertrophy as the possible reason of increase in body cellular and muscular mass.

Present forwards exhibited higher glycogen content than backwards, hence, forwards were found to be superior than back and less prone to fatigue up to a certain level of exercise and the same was supported Zyla et al. (23) where they revealed a direct relationship between fatigue and muscle glycogen content. Gabbett (21) also predicted

Table 1. Comparison of Mean (\pm SD) of Various Anthropometric Parameters and Body Composition Profiles of Indian National Women Rugby Players According to Their Field Position

Parameters	Forward (N = 12)	Back (N = 13)	T Value	P Value
Height, cm	159.1 \pm 5.23	156.9 \pm 4.51	1.158 (NS)	0.259
Weight, kg	57.5 \pm 7.50	49.5 \pm 4.93	3.195 ^a	0.004
BMI, kg/m ²	22.9 \pm 2.79	20.0 \pm 1.72	3.130 ^a	0.005
FM%	22.7 \pm 5.56	17.2 \pm 3.70	2.947 ^a	0.007
FFM%	77.3 \pm 5.56	82.8 \pm 3.70	2.947 ^a	0.007
Sum of skinfold, mm	51.8 \pm 10.51	39.4 \pm 11.39	2.842 ^a	0.009
W:H ratio	0.76 \pm 0.04	0.77 \pm 0.04	0.317 (NS)	0.756
PEHR, beats/min	77.7 \pm 9.21	74.5 \pm 9.69	0.848 (NS)	0.405
BCM, kg	19.2 \pm 2.12	17.7 \pm 1.37	2.124 ^b	0.045
BCM/kg body wt.	0.33 \pm 0.02	0.36 \pm 0.02	2.961 ^a	0.007
MM, kg	23.1 \pm 2.93	21.1 \pm 1.71	2.145 ^b	0.043
MM/kg body wt.	0.40 \pm 0.02	0.43 \pm 0.02	2.566 ^b	0.017
Pr. content, kg	9.0 \pm 0.79	8.8 \pm 0.72	0.637 (NS)	0.530
Pr. content/kg muscle	0.39 \pm 0.05	0.42 \pm 0.03	1.512 (NS)	0.146
TBK, gm	102.4 \pm 12.96	91.7 \pm 6.30	2.651 ^b	0.014
TBCa, gm	856.9 \pm 100.73	762.7 \pm 66.23	2.785 ^b	0.011
Glycogen, gm	406.0 \pm 43.07	370.7 \pm 23.41	2.575 ^b	0.017
Mineral, kg	3.7 \pm 0.32	3.6 \pm 0.29	0.623 (NS)	0.539
Hemoglobin, mg/dL	11.2 \pm 0.80	11.5 \pm 1.22	0.668 (NS)	0.511
R. glucose, mg/dL	108.9 \pm 9.66	108.0 \pm 10.75	0.225 (NS)	0.824

Abbreviations: BCM/kg body wt., relative BCM; BCM, body cell mass; FFM%, fat free mass percentage; FM%, fat mass percentage; MM/kg body wt., relative MM; MM, muscle mass; NS, not significant; PEHR, pre exercise heart rate; Pr. content, protein content; R. glucose, random blood glucose; TBCa, total body calcium; TBK, total body potassium; W: H ratio, waist hip ratio.

^a P < 0.01.

^b P < 0.05.

Table 2. Comparison of Mean (\pm SD) of Various Physical Fitness Parameters of Indian National Women Rugby Players According to Their Specific Playing Position

Parameters	Forward (N = 12)	Back (N = 13)	T Value	P Value
HGS-R, kg	29.4 \pm 4.60	28.0 \pm 4.17	0.848 (NS)	0.406
HGS-L, kg	26.7 \pm 4.38	25.7 \pm 3.97	0.582 (NS)	0.567
RBS, /kg wt.	1.3 \pm 0.21	1.5 \pm 0.17	1.596 (NS)	0.125
Flexibility, cm	17.4 \pm 4.19	16.5 \pm 4.83	0.676 (NS)	0.506
30 m flying start	5.6 \pm 0.32	5.3 \pm 0.45	1.448 (NS)	0.161
Agility test, km/h	12.7 \pm 0.56	13.1 \pm 0.43	2.306 ^a	0.030
SBJ, m	1.7 \pm 0.23	1.9 \pm 0.11	2.735 ^a	0.012
VO ₂ max, ml/kg/min	35.8 \pm 4.65	40.2 \pm 4.66	2.368 ^a	0.027
A power, watt	325.4 \pm 63.85	337.9 \pm 75.32	0.0443 (NS)	0.662
R power, watt/kg	5.6 \pm 0.69	6.9 \pm 1.51	2.702 ^a	0.013

Abbreviations: A power, absolute peak anaerobic power; HGS-L, hand grip strength (left); HGS-R, hand grip strength (right); NS, not significant; R power, relative peak anaerobic power; RBS, relative back strength; SBJ, standing board jump.

^a P < 0.05.

the higher glycolytic agility in forwards which corroborates with our findings. Forwards of the present study were also found to have higher quantity of TBK and TBCa. According to Debnath et al. (24) and Sarkar et al. (25) higher TBK or TBCa may help the players to maintain their electrolytes balance in body fluids.

Success in rugby requires higher level of muscular

strength and power, particularly for the forwards than backs (26). Muscle strength is required during tackling the contact situations (5). Present study also corroborates with the above finding as forwards possess higher hand grip and relative back strength as compared to the backs though the difference was statistically insignificant.

It is well documented that elite rugby players require

Table 3. Pearson's Product Moment Correlation Coefficient of Some Selected Body Composition Variables with Various Selected Variables of Indian National Women Rugby Players

Variables	Weight	BMI	RBS	Flex	30 m Flying	Agility	SBJ	VO ₂ max	R Power	Skinfold
Sum of skinfold	0.609 ^a	0.499 ^b	-0.285	0.050	0.459 ^b	-0.197	-0.283	-0.538 ^a	-0.561 ^a	1
MM/kg wt	-0.581 ^a	-0.723 ^a	0.552 ^a	-0.306	-0.359	0.312	0.313	0.553 ^a	0.421 ^b	-0.617 ^a
BCM/kg wt	-0.663 ^a	-0.859 ^a	0.431 ^b	-0.273	-0.388	0.350	0.350	0.531 ^a	0.349	-0.569 ^a

Abbreviations: BCM/kg wt, body cell mass/kg body weight; BMI, body mass index; flex, trunk flexibility; MM/kg wt, muscle mass/kg body weight; R power, relative peak anaerobic power; RBS, relative back strength; SBJ, standing board jump; skinfold, sum of skinfold thickness.

^a Significant correlation at 0.01 level (2 tailed).

^b Significant correlation at 0.05 level (2 tailed).

Table 4. Prediction of Regression Coefficient Based on Linear Regression Model of the Present Subject

Variables	R ²	Adjusted R ²	β	T Value	Significance
Relative peak power	0.644	0.612			
Agility			0.586	4.515	0.000
Sum of skinfold			-0.446	3.436	0.002

Table 5. Principle Component Analysis of Various Anthropometric and Motor Ability Parameters According to the Specific Field Positions of Women Rugby Players

Parameters	Eigen Value	Percentage of Variance	Coefficients of PC1	Coefficients of PC2
BMI	3.1747	52.91	-0.3211	0.6109
Sum of Skinfold	1.0708	17.85	-0.3935	0.4686
Agility	0.7465	12.44	0.4009	0.5133
SBJ	0.5411	9.02	0.4025	0.2466
VO ₂ max	0.3141	5.23	0.4712	-0.0957
Rel. power	0.1529	2.55	0.4442	0.2716

Abbreviations: BMI, body mass index; Rel. power, relative peak anaerobic power; SBJ, standing board jump.

well-developed speed, agility, and explosive power of leg muscle to fulfill the physiological need during a match (i.e., running, dashing, sprinting, acceleration and rapid change in direction etc.) and to enhance the post-match recovery process (3, 4, 10, 27). Players of back positions were intended to cover more distance by walking, running and sprinting than forwards (28). Present backs were reported to have better agility, explosive power of lower limbs, and relative anaerobic peak power than forwards and corroborate with the findings of Durandt et al. (22). They have identified some optimal training adaptation in terms of sprinting momentum, body balance, and sensory motor coordination with proper muscular hypertrophy among these playing positions (29). All these alterations in body composition and physical performance indices may stimulated due to the skill-based conditioning of the game in different positions than traditional condition (30).

Energy contributions during a high intensity team game activity are primarily anaerobic in nature and required during tackles, explosive acceleration, and scrimmaging, mauling and rucking (31). Forwards are able to produce higher absolute, peak and mean power output as compared with backs (32). But sometime relative anaerobic power was found to be similar or slightly higher in back as compared to forward and the above findings corrobo-

rates with the present result (33).

Maximum O₂ uptake is as an indicator of aerobic fitness of rugby players. High VO₂max enhances the ability to exercise with higher repetition of high intensity activity (34). Forwards are reported to have more absolute VO₂max as compared to backwards and vice-versa for the body weight adjusted relative values (35, 36). Almost similar observations were recorded by the present study. The absolute value of VO₂max are slightly more in forwards and this is indicated the capacity for a high aerobic power production.

Linear regression model identifies agility and sum of skinfold as the principle predicting parameters for relative peak power (F value = 19.922) at P < 0.001 level. The present study stated that a higher sum of skinfold was associated with poorer agility, explosive power of lower limbs, endurance capacity and relative peak anaerobic power. The Eigen value and percentage of variance from the descriptive statistics of principle component analysis identified BMI, sum of skinfold and agility as the principle confounding variables for categorizing the present national women rugby players between forward and back positional groups.

5.1. Conclusions

The present study identified the backs as faster, more agile and aerobically superior with lower body weight and fat mass proportion than forwards. The linear regression analysis revealed that the sum of skinfold, relative muscle mass and relative body cell mass was the most correlated parameters to almost all physical fitness variables. Whereas, principal component analysis identified the BMI, sum of skinfold and agility as the main differentiating variables between the positional groups of women rugby players. Data of the present findings could be useful for the rugby players to formulate the systematic conditioning training programme as per the positional demands and to diminish the chances of overtraining and injury through a training session. Further research is needed in this field to unfold the physical characteristics and fitness requirements of women rugby players of India.

Acknowledgments

The authors express their sincere gratitude to the players for their valuable participation in the present study and SAI, Eastern Centre, Kolkata for providing facilities to conduct the study.

Footnotes

Authors' Contribution: Surojit Sarkar: manuscript preparation, statistical process, data collection and analysis; Swapan Kumar Dey: review of literature, analysis of data, manuscript correction.

Conflict of Interests: The authors declare no conflict of interest.

Ethical Considerations: The present study followed the ethical guideline of Declaration of Helsinki (1975) and an informed consent was obtained from every players (44/SAI/HPL/2018-19).

Funding/Support: Support was given by Sports Authority of India regarding the present study.

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