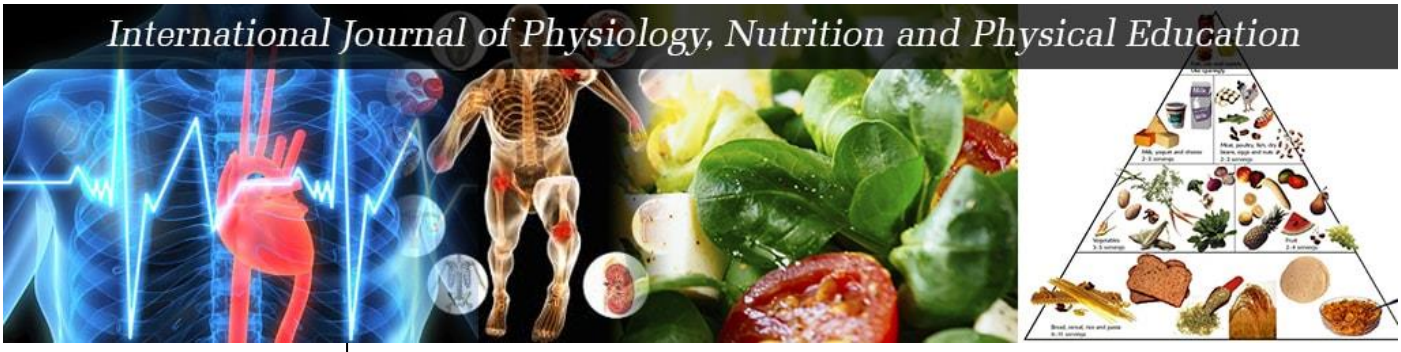

ISSN: 2456-0057
IJPNPE 2019; 4(2): 191-195

www.journalofsports.com
Received: 06-05-2019
Accepted: 08-06-2019

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A study on position wise differences in anthropometric and physiological variables of basketball players

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Abstract
Purpose of the study is to see whether selected anthropometric and physiological variables effectively discriminate between guards, forwards and centre players of basketball game. To realize this purpose, 600 male basketball players from different parts of Karnataka were randomly selected for the study. The age ranged from 12 to 32 years. Guards (N=200), forwards (N=200) and centers (N=200) represented their specific playing positions. Height, weight, sitting height, arm span, four width measurements, three girth measurements, five skin folds were measured. Physiological variables namely vital capacity and blood pressure were measured. All the anthropometric variables transformed as the stature adjusted variables using Ross and Wilson's (1975) unisex human model (Z-scores). Step wise discriminant analysis was used to find out the group membership. Results revealed that height, stature adjusted forearm girth, stature adjusted supra-spinale skin fold, stature adjusted medial calf skin fold, stature adjusted mid-thigh skin fold, stature adjusted medial calf skin fold, stature adjusted triceps skin fold, stature adjusted leg length, stature adjusted bi-iliocristal width, peak expiratory flow and stature adjusted femur width were entered into the discriminant function in a stepwise progression. For function-1 Wilk's lambda of 0.623, canonical correlation of 0.509 and chi square of 271.703wereall significant at α=0.05 level. For function-2, Wilk's lambda of 0.853, canonical correlation of 0.383 and chi-square of 93.86 were also significant at α=0.05 level. 61.2% players were correctly classified in their respective groups. Height and stature adjusted mid-thigh skin folds contributed high in both functions.

Keywords: Basketball, Anthropometric, physiological, player positions, physical fitness

Introduction
Team sport performance is dependent upon a diverse range of qualities including size, fitness, sport-specific skills, team tactics, and psychological attributes. The game of basketball has evolved to have a high priority on body size and physical fitness by coaches and players. A player's size has a large influence on the position in the team, while the high-intensity, intermittent nature of the physical demands require players to have a high level of fitness (Drink Water E J *et al*.2008) [4]. Basketball requires an extremely pronounced body height and some other linear measures. They chiefly influence the performance of certain specific basketball movements with a pronounced vertical component (rebounds, different shots, blocking of shots, jumping at the jump ball etc.)In addition to linear dimensions, the efficiency of playing performance is affected to a smaller extent by transvers dimensions, body volume and fat tissue (Dežman 1988; Erčulj, 1996).

There are different types of players in basketball, based on position they play namely, guards, forwards and centers in terms of the roles they play in the game. Due to the specifics of each position, differences can be found amongst players in terms of their physical, physiological and psychological characters. It is also true for the morphological characteristics of basketball players playing at different positions (Dežman *et al*., 2001; Erčulj, 1998; Jeličić *et al*., 2002; Trninić *et al*., 1999). The most apparent differences are in the linear dimensions; however, to some extent the basketball player types have a specific structure of transvers dimensions, circumferences and fat tissue. Subcutaneous fat negatively affects the playing efficiency of basketball players mainly playing in perimeter positions, i.e. guards and forwards (Dežman 1988; Erčulj, 1996), whereas centers of the highest quality across different age categories often have a slightly higher percentage of fat tissue compared to the perimeter players (Bale, 1986; La Monte *et al*., 1999; Spurgeon *et al*., 1981).

Physiological parameter is also a major factor in game of Basketball. Vital capacity, aerobic and anaerobic power, blood pressure are the main factors. Players playing at different positions need these but varies from position to position. Daragan, Marinkovic and Slobodan Pavlovic (2013) [8] studied VO $_{2(max)}$ of university basketball players in Serbia. It was found that players in the guard positions had a largest value of VO $_{2(max)}$ while centers had the lowest values. CheryllDidi and N. Obra (2008) studied physiological characteristics of elite collegiate basketball players of Illicos Norte (northern Philippines) at different playing positions and established statistically significant difference in peak oxygen consumption of players with the guards having higher $VO_{2(max)}$ values while the centers having the lowest values. Gocentas Audrius *et al*. (2011) examined possible differences in cardio respiratory functional capacity between perimeter (guards & forwards) and post (center) players among elite basketball players. All players performed a standardized exercise test to evaluate $VO_{2\ (max)}$ using a cycle ergometer and automated breath-by-breath analysis system VMAX229C (Developed by Sensor medics Corp., Yorba Linda, CA USA). They also collected data of aerobic power, heart-rate, pulmonary ventilation and gas exchange and compared the groups of perimeter and post players on these parameters. Significant differences in subgroups were observed. The perimeter players had significantly higher values of VO $_{2(max)}$ and relative power relative to post-players. VO $_{2(max)}$ was related to relative power. A number of attempts have been made by various researchers to establish differences in anthropometric variables of basketball players playing at different positions. But these anthropometric variables are directly compared. Anthropometric measures cannot be used in the direct comparison of two populations unless they are adjusted for height or ratios are worked out. Ratios, however pose statistical and interpretational problems (Carter 1978). For example a large value of the branchio-antebranchial index could reflect variety of conditions: large forearm versus normal arm length or any combination of largeness in the forearm and shortness in the arm. Secondly, because the variance of ratio is an inextricable combination of the variance of the numerator and denominator the use of such ratios in correlational matrixes or analysis of variance defies meaningful interpretation (Ross and Marfell- Jones 1982). To circumvent these problems, Ross and Wilson (1974) developed a stratagem using a single unisex reference human or "phantom" for proportionality analysis, called the Phantom stratagem. Methodologically, this approach has the advantage that all individuals are adjusted to the same stature and that separate variables are all converted to Z-scores, which facilitates between group, between sex and among variable comparisons. No studies have been found using discriminant statistical analyses which is used to determine which variables discriminate between two or more naturally occurring groups. Outcome of this study, therefore, may help coaches and administrators to find the talent at the earliest stage and design their training programme according to requirement of the specific positional of basketball players.

Objective of the study

Purpose of the study was to find out differences in selected anthropometric variables and physiological variables for effectively discriminating between guards, forwards and center players of basketball game.

Methods

600 male basketball players of Karnataka state who represented their club, district, division and state team were served as the samples for the study. In that guards (N=200), forwards (N=200) and centers (N=200). The age of the samples was ranged between 12 and 32 years. Data was collected from Karnataka State Basketball Association's different age group tournaments, School Game Federation of India's different age group's district, division and state level tournaments and different invitational tournaments which was organized by basketball clubs of Karnataka state during the 2018-19 season. Anthropometric measurements Height, Stature weight, sitting height, arm span, bi-acromial shoulder width, bi-iliocristal width, bi-epicondyler humorous width, bi-epicondyler femur width, flexed arm girth, forearm girth, calf girth, sub scapular skin fold, supra-spinale skin fold, triceps skin fold, medial calf skin fold and mid-thigh skin fold were measured. Physiological variables including Forced vital capacity, forced expiratory volume, peak expiratory flow, systolic blood pressure and diastolic blood pressure were measured.

Data transformation

Except height all other anthropometric values were converted to Phantom-Z score by using mean and standard deviation of Ross and Wilson's (1975) unisex human model. Body mass index was calculated using height and weight. Body density was calculated using Sloan's formula and percent body fat calculated using Brozek's formula (Human Body measurements- Concepts and applications, S P Singh and P Mehta, PHI learning private limited, p.no.-88 and 96).

Statistical Technique

The discriminant analysis in SPSS statistical package (Version 21.0) was used to get the required result. For the statistical analyses the level of significance was kept at 0.05.

Findings

Presented in table-1 are mean, standard deviation and F-ratio of guards, forwards and centers.

Table 1: Mean, Standard deviation, & F-Ratio of Physiological Measures and Phantom Z-Scores of Anthropometric Measures of Guards, Forwards and Center Basketball Players

Variables	Guards (N=200) Mean &SD	Forwards (N=200) Mean &SD	Center (N=200) Mean &SD	F-Ratio
Height	164 ± 10.42	168.69±10.11	173.99±11.17	41.08*
SA$^+$ Weight	-0.84 ± 1.34	-0.70±1.48	-1.00±1.19	2.49
SA$^+$Leg length	1.22 ± 0.77	1.09±0.79	1.42±0.88	8.71*
SA$^+$Arm Span	0.28 ± 0.64	0.21± 0.57	0.18±0.46	1.49
SA$^+$Bi acromial shoulder width	-0.64 ± 1.09	-0.59±1.17	-0.47±1.31	1.09
SA$^+$Biilleocristal Width	-1.48 ± 1.68	-1.25±1.53	-1.89±1.66	7.80*
SA$^+$Biepicondyler Humorous width	0.81 ± 1.53	0.80±1.27	0.49±1.73	2.84*
SA$^+$Biepicondyler Femur Width	-0.21 ± 1.39	-0.22±1.36	-0.22±1.71	0.00
SA$^+$Flexed arm Girth	-1.15 ± 1.32	-1.08±1.29	-0.93±1.38	1.39

SA+Relaxed forearm Girth	-0.48 ± 1.22	-0.87±1.18	-1.13±1.12	15.28*
SA+Calf Girth	1.11 ± 1.36	1.31±1.51	1.08±1.06	1.89
SA+Mid-thigh skin fold	-1.20 ± 0.62	-0.96±0.69	-1.10±0.57	7.15*
SA+Triceps skin fold	-0.16 ± 1.22	0.11±1.11	-0.19±0.90	4.71*
SA+Sub scapular skin fold	-0.99 ± 0.86	-0.93±0.93	-0.92±0.80	0.31
SA+Supraspinale skin fold	-0.26 ± 1.46	-0.29±1.35	0.15±1.42	6.01*
SA+Medial Calf skin fold	-0.46 ± 1.16	-0.07±1.14	-0.33±1.03	6.27*
Body Mass Index	19.74 ± 3.01	20.56±3.58	20.56±3.06	4.33*
Body Density	1.07 ± 0.01	1.06±0.01	1.06±0.008	10.00*
Body Fat %	14.16 ± 4.04	15.75±4.47	15.66±3.43	9.93*
Forced Vital Capacity	1.76 ± 0.67	1.67±0.52	1.72±0.56	1.24
Forced Expiratory Volume	1.71 ± 0.62	1.64±0.51	1.68±0.53	0.68
Peak Expiratory flow	5.11 ± 1.96	4.76±1.81	4.99±1.65	1.98
Systolic Blood Pressure	116.17±10.03	118.48±10.88	116.41±8.12	3.39*
Diastolic Blood Pressure	73.74 ± 10.22	72.66±8.69	74.76±7.14	2.84*

+SA= Stature adjusted, $p<0.05$

The obtained values in table-1 reveal that the height, stature adjusted leg length, stature adjusted bi-iliocristal width, stature adjusted bi-epicondyler humorous width, stature adjusted forearm girth, stature adjusted supra-spinale skin fold, stature adjusted triceps skin fold, stature adjusted medial calf skin fold, stature adjusted mid-thigh skin fold, body mass index, body density, percent body fat, systolic blood pressure and diastolic blood pressure, showed significant F- ratios.

Of the 25 variables under study 14 variables were found to be significant as stated earlier. Therefore it was decided to subject the data to post-hoc analyses to locate significant differences between any set of two means. The difference between means obtained upon post hoc analyses for Guards, Forwards and Centers are furnished in the table-2.

Table 2: Mean differences between Guards, Forwards and Centers of Basketball players in the variables that were entered in the discriminant analyses

Variables	Guards Vs Forwards	Forwards Vs Center	Guards Vs Center
Height	-4.36*	-5.29*	-9.66*
SA+ Weight	-0.14	0.29*	0.16
SA+Leg length	0.13	0.34*	-0.20*
SA+Arm Span	0.70	0.02	0.09
SA+Bi acromial shoulder width	-0.04	-0.12	-0.17
SA+Biilleocristal Width	-0.22	0.63*	0.41
SA+Biepicondyler Humorous width	0.01	0.30*	0.32*
SA+Biepicondyler Femur Width	0.003	-0.002	0.001
SA+Flexed arm Girth	-0.06	-0.21	-0.15
SA+Relaxed forearm Girth	0.38*	0.26*	0.64*
SA+Calf Girth	-0.20	0.23	0.02
SA+Mid thigh skin fold	-0.24*	0.14*	-0.10
SA+Triceps skin fold	-0.27*	0.30*	0.02
SA+Sub scapular skin fold	-0.05	-0.009	-0.06
SA+Supraspinale skin fold	0.01	-0.43*	-0.42*
SA+Medial Calf skin fold	-0.38	0.26	-0.11
Body Mass Index	-0.82*	-0.005	-0.83*
Body Density	0.003*	-0.0001	0.003*
Body Fat %	-1.58*	0.08	-1.50*
Forced Vital Capacity	0.09	0.04	-0.04
Forced Expiratory Volume	0.06	0.03	-0.03
Peak Expiratory flow	0.36	-0.23	0.12
Systolic Blood Pressure	-2.31*	2.06*	-0.24
Diastolic Blood Pressure	1.07	-2.09*	-1.01

+SA= Stature adjusted, *$p<0.05$

It could be noted in table-2 that height, stature adjusted relaxed forearm girth, stature adjusted mid-thigh skin fold, stature adjusted triceps skin fold, body mass index, body density, percentbody fat(%F_b)and systolic blood pressure were found to be significantly different between Guards and Forwards. When Forwards and Centers were compared height, stature adjusted weight, stature adjusted leg length, stature adjusted bi-iliocristalwidth, stature adjusted bi-epicondyler humorous width, stature adjusted forearm girth, stature adjusted mid-thigh skin fold, stature adjusted triceps skin fold, stature adjusted supra-spinale skin fold, systolic blood pressure and diastolic blood pressure were found significantly different. When guards and centers were compared height, stature adjusted leg length, stature adjusted bi-epicondyler humorous width, stature adjusted forearm girth, stature adjusted supra-spinale skin fold, body mass Index, body Density and percent body Fat were found significant between them. The result of the discriminant analyses are summarized in table No. 3.

Table 3: Discriminant analyses for Guards, Forwards and Centers of Basketball players

Anthropometric and Physiological variables	Discriminant Loading	Canonical correlation's	Wilk's Lambda	Chi-square
Height	0.624	0.509	0.632	271.703*
SA+Mid thigh skin fold	0.366	0.383	0.853	93.86*
SA+ Fore arm Girth	-0.363			
SA+Supraspinale skin fold	0.226			
SA+ Medial calf skin fold	0.349			
SA+ triceps skin fold	0.290			
SA+ Leg length	-0.271			
SA+ Bi illeocristal Width	0.238			
Peak Expiratory flow	-0.195			
SA+ Femur Width	-0.002			

+SA= Stature adjusted, *p<0.05

Anthropometric and physiological variables viz., Height, stature adjusted forearm girth, Stature adjusted supra-spinale skin fold, Stature adjusted medial calf skin fold, Stature adjusted mid-thigh skin fold, Stature adjusted medial calf skin fold, Stature adjusted triceps skin fold, Stature adjusted leg length, Stature adjusted Bi-iliocristal width, peak expiratory flow and Stature adjusted femur width were accepted into the discriminant function in a stepwise progression.

The size of the discriminant loadings indicated that Height, Stature adjusted forearm girth, Stature adjusted supra-spinale skin fold made highest contribution to function 1. Stature adjusted medial calf skin fold, Stature adjusted mid-thigh skin fold, Stature adjusted medial calf skin fold, Stature adjusted triceps skin fold, Stature adjusted leg length, Stature adjusted Bi-iliocristal width, peak expiratory flow and Stature adjusted femur width made highest contribution to function 2.

The discriminant functions with the anthropometric and psychological characters were significant as indicated by chi-square values for function-1 (271.703) and function-2 (93.86). The chi-square values of both the functions were well beyond the 0.05 probability level. The wilk's lambda (0.632for function-1; 0.853 for function-2) and significant canonical correlation (0.509 for function-1 and 0.383 for function-2) suggested that the functions produced the modest degree of separation between the three groups under study, viz., Guards, Forwards and Centers of basketball game.

Mean discriminant scores of Guards, Forwards and Center position basketball players for two functions are provided in table no.4. Since it was a three group discriminant analysis, it was necessary to calculate two canonical discriminant functions in order to discriminate between the three groups. The first function separated one group from another two; the second function separated one group from remaining one group.

Table 4: Canonical discriminant functions for Guards, Forwards and Centers of Basketball players

Playing position of the player	Function	
	1	2
Guard	-.615	-.395
Forward	-.181	.571
Centre	.796	-.176

When looking at function-1, one can observe that the centroides for group one (guards) is -0.615, for group two (forwards) it is -0.181 and for group three (centers) 0.796. Therefore it was concluded that function-1 significantly separated centers from guards and forwards and function-2 significantly separated forwards from guards. This was supported by chi-square result (Table no.3). These centroides were presented in graphically in figure-1.

Table 5: Classification result for Guards, Forwards and Centers of Basketball players

Actual Group	Predicted group Membership			Total
	Guards	Forwards	Centers	
Guards	120 (60.0%)	43 (21.5%)	37 (18.5%)	200 (100%)
Forwards	48 (24.0%)	111 (55.5%)	41 (20.5%)	200 (100%)
Centers	35 (17.5%)	29 (14.5%)	136 (68.0%)	200 (100%)

The classification result of Guards 60%, Forwards 55.5% and centers 68%were found more than the chance occurrence of 45.55%. Hair (1987) have suggested that in the absence of a hold-out sample, the classification accuracy should be at least 12.5% greater than that achieved by chance. In the present study, in the discriminant analyses involving three groups with equal sample size (N=200) a chance of 33.33% defines the classification accuracy. Therefore, wherever three groups were compared, if grouped cases classified were more than45.88% (33.33%+12.5%) respectively it was accepted as an accurate classification

The classification results have demonstrated that 61.2% of the grouped cases were correctly classified. Hence it was accepted as an accurate classification. The classification of cases is graphically illustrated in figure no.1 indicating the location of centroids and the cluster of the cases about their mean values in the discriminant space.

The result of discriminant function indicated that the anthropometric and physiological variables could effectively discriminate between the Guards, Forwards and Center positional basketball players was well supported.

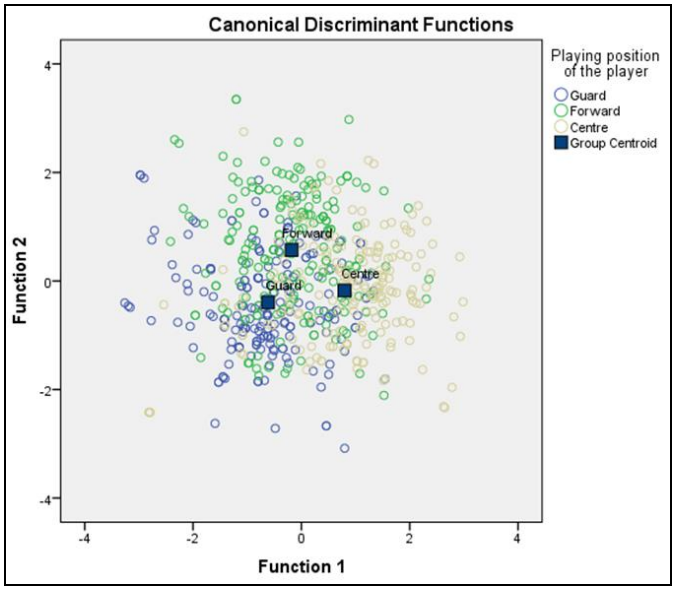

Fig 1: Canonical Discriminant function for showing separation of individual group Under-14 cricket players

Discussion and conclusion

The idea that selected anthropometric and physiological variables effectively discriminate guards, forwards and centers effectively is well supported. When theuni-variateF-ratios are observed, except stature adjusted weight, stature adjusted arm span, stature adjusted bi-acromial shoulder width, stature adjusted bi-epicondyler femur width, stature adjusted flexed arm girth, stature adjusted calf girth, forced vital capacity, forced expiratory volume and peak expiratory flow and all other variables were significantly different. As predicted, centers were tallest with longer leg length among three groups, because of their requirement near the rim. They also have higher body mass index and percent body fat. Guards have to move quickly throughout the court so they required less percent body fat and more vital capacity. Result of the study shows that guards are having less percent body fat than other two and less significant vital capacity than the centers.

A careful examination of the correlation matrices for the variables that were entered into the computations indicate that stature adjusted weight shows multi-co-linear relationship with stature adjusted arm girth, stature adjusted forearm girth, stature adjusted calf girth, stature adjusted triceps skin fold, stature adjusted sub scapular skin fold, stature adjusted supra-spinale skin fold, body mass index, body density and percent body fat. Stature adjusted flexed arm girth showed multi-co-linear relationship with stature adjusted weight, stature adjusted forearm girth, stature adjusted calf girth, stature adjusted triceps skin fold, stature adjusted sub-scapular skin fold, stature adjusted supra-spinale skin fold, body density and percent body fat. It seems, therefore, that stature adjusted weight and stature adjusted flexed arm girth were partialed out in the discriminant analyses. Peak expiratory flow is highly correlated with forced vital capacity and forced expiratory flow. Therefore, only peak expiratory flow variable was likely to be entered in the discriminant function.

Based on the results of the study it was concluded that guards, forwards and centers may be effectively identified based on stature adjusted anthropometric and physiological variables. Height and mid-thigh skin fold made highest contribution in function-1 and function-2. These were supported by significant chi-square value, wilk'slamda and canonical correlations. Discriminant function for all three groups was significant and showed correct classification over 45.88%. Variables related to skin folds were dominated over other variables in the discriminant functions.

Acknowledgement

Author extends his gratitude to Dr. Anand Nadgir, Retd. Principal, Shri K. G. Nadgir College of Phys. Ed. Dharwad, Karnataka for his valuable suggestions in making this article possible.

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