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Original Article

Physiology Section

Anthropometric Correlates for the Physiological Demand of Strength and Flexibility: A Study in Young Indian Field Hockey Players

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ABSTRACT

Introduction: Optimal strength and flexibility are essential for performance enhancement and injury prevention in hockey, and anthropometry is known to influence these parameters.

Aim: To find anthropometric correlates for strength and flexibility score in young Indian field hockey players.

Materials and Methods: Thirteen female and 19 male subjects volunteered for the study. Selected anthropometric variables: lengths, breadths, girths and body composition; strength and sit and reach score were measured for each subject.

Results: Males were taller, leaner and stronger with longer upper limbs and broader chests. With few exceptions, taller, heavier and leaner players with longer trunks and limbs, broader chest and hip, and bulkier arms and lower limbs had stronger grip, back, upper and lower limbs. Heavier and taller players with longer trunk and more percentage of body fat were more flexible. Also, the stronger players had more percentage body fat and body mass index, which might be due to the strong positive correlation of percentage body fat and body mass index with fat free mass.

Conclusion: Anthropometric variables, especially heights, breadths and body composition, show significant correlation with strength and flexibility, and hence may serve as monitoring tool and for talent identification.

Keywords: Back strength, Body composition, Hand grip, Hockey, Seated shot put throw, Sit and reach score, Vertical jump

INTRODUCTION

Field hockey is one of the most popular and played sports throughout the world. It is also the national game of India. It is a team game which requires a characteristic anthropometric profile [1-3] optimum for the heavy physiological demand [1,4-6], the game seeks from its players. Strength and power [1,7] are another major components which have high impact over this game, as the game involves large number of changes of direction, accelerations, decelerations, sprinting [8-10], and other skills with the ball [1,7].

Back and hamstring flexibility, besides strength and endurance, is an important component of healthy back functions, which is very essential in field hockey not only for maximal performance but also to avoid sports related injuries. The players in the field hockey are required to bend forward to the ground for maximum groundwork and for wider range during the game [11]. The back muscles may get fatigued and strained. Motor imbalance may also occur which may cause tight hip flexors, tight hamstrings etc., predisposing to musculoskeletal injuries.

The present study was designed to evaluate selected anthropometric, strength and flexibility variables, and to study their correlations among national level young field hockey players.

MATERIALS AND METHODS

This cross-sectional and analytical study was conducted from August to September 2013 under Sports Sciences and Fitness Centre, North-East Regional Centre (NERC), Sports Authority of India (SAI), Imphal, India. Thirteen female and 19 male players among the field hockey trainees of NERC, SAI volunteered for the study. Due to limited availability of the trainees at the institute satisfying the study criteria, the sample size of the study was relatively small. Those players who were healthy and participated in any recognized national level competitions were included. Players who did not give informed and written consent, and found unfit during medical screening and pre-participatory physical evaluation were excluded. The study was approved by the Ethical Committee of the Institute.

All the players were instructed to report at 8 am to 9 am after a sound night sleep of eight hours and mild breakfast for testing [12,13]. Physical exertion was not allowed before 12 hours of the testing [14]. No heavy solid food or caffeinated drink was allowed before four hours of the testing [14]. They were made to relax and asked to empty their bladder at least 30-60 minutes before the testing [15]. After explaining clearly the purpose and procedure, each individual test was conducted.

Standing height (HT) and Sitting Height (SH) were measured using a Stadiometer (Holtain Ltd., Crymych, Dyfed, UK) and a 50 cm wooden box to the nearest 0.1 cm [16]. Body weight (BW), body composition variables {Fat Free Mass (FFM), percentage body fat (%BF)} and Body Mass Index (BMI) were measured using TANITA Body Composition Analyzer (TBF310 Model, Japan), which is based on a patented foot to foot pressure contact electrode using Bioelectrical Impedance Analysis technique [17,18].

The procedures outlined by ISAK (International Society for the Advancement of Kinanthropometry) were followed in recording structural dimensions and girths [13,19]. Segmometer (Rosscraft) was used for measuring segmental lengths {acromiale-stylion length (AS) and midstylion-dactylion length (SD)} and height {trochanterion height (TH)}. For measuring large and small breadths {biacromial breadth (AB), biiliocristal breadth (IB), biepicondylar humerus breadth (HB) and biepicondylar femur breadth (FB)}, large and small sliding calipers (Rosscraft) were used. A flexible and non-stretchable steel tape (Holtain Ltd.,) was used for measuring girths {relaxed arm girth (AG), mid-thigh girth (TG) and calf girth (CG)}.

Strength of each hand grip (left: LG and right: RG) and back (BS) was measured using a hydraulic handgrip dynamometer (Baseline Hand Evaluation set 12-0100, NY 10602, USA) and an arm-leg and back pull electronic dynamometer (Strength Evaluation System IMI-1429, Indian Medico Instruments, Delhi) respectively, following the standard procedures [16].

Seated shot put throw test (SP) was used to assess the speed, strength quality and power of the upper limb musculature, following the standard methodology [20]. The angle of shot put released was not controlled in our study. Strength quality and explosive power in the lower limb musculature was assessed by vertical jump score (VJ) [21-27], conducted following the standard methodology [28].

A sit and reach instrument (model-01285A, Lafayette Instrument Company, IN 47903, USA) was used to assess lower back and hamstring flexibility (F) following the standard methodology [29,30]. The level of feet was used as the zero mark.

STATISTICAL ANALYSIS

Standard descriptive statistics were determined for the measured variables. They were categorized into: non-modifiable and modifiable parameters. Normality was assessed using Shapiro-Wilk test. Independent t-test was used for comparison between the genders. The relationships among various variables were studied using Pearson's zero-order correlation and partial correlation, controlling for the effect of gender. Statistical significance was set at p-value (2-tailed)<0.05. SPSS (Statistical Package for Social Science) version 20 software was used for data analysis.

RESULTS

[Table/Fig-1] shows the descriptive statistics and also the comparison between female and male players. Significant differences (p-value<0.05) were noted in HT, AS, SD, AB, FFM, %BF, TG, LG, RG, SP, BS and VJ between the groups.

The association between the non-modifiable and modifiable anthropometric variables with strength and flexibility variables was studied by evaluating zero-order Pearson's correlation r-values for the two groups. In order to study the association in the studied subjects as a whole independent of the effect of gender, partial correlation r-values were evaluated using gender as covariate. [Table/Fig-2,3] show the correlation r-values. After controlling gender, strength variables had significant positive correlation (p-value<0.05) with age (exception: VJ), HT, SH, AS (exception: RG and BS), SD (exception: RG and VJ), TH (exception: BS), AB, IB (exception: BS and VJ), DOT (duration of training; exception: BS and VJ), BW, FFM, %BF (exception: VJ), BMI (exception: VJ), AG (exception: VJ), TG (exception: BS and VJ) and CG (exception: BS and VJ). Similarly, F had significant positive correlation (p-value<0.05), after controlling gender, with age, HT, SH, BW and %BF.

DISCUSSION

Hockey is a game in which successful performance is influenced by anthropometric characteristics [1,2] apart from physiological [1,4-6] and skill variables. In our study, the males were taller, leaner and stronger with longer upper limbs and broader chests [Table/Fig-1]. The bulkier thigh of female players might be due to more fat deposition [31] or might be merely a coincidental finding. However, there was no significant difference as far as BMI and flexibility score were concerned between the two groups [Table/Fig-1]. As both the groups were of comparable ages, had similar habitual physical activity, and given similar training and diet for similar duration, the differences in both the groups might be due to gender specific physiology [18,32].

Strength [1,7,8,10] and sprint training [8-10] are very important in field hockey as many explosive activities [8,9] and repeated back-to-back sprints [8-10] are common in it. In our study, age and DOT had significant positive correlation with various strength variables (exception: BS with DOT; and VJ with age and DOT) and F (exception: DOT), when gender was controlled for [Table/Fig-2,3]. Also, with increasing age and duration of training, male players showed improvement in strength and flexibility [Table/Fig-2,3].

Parameters		Males (n=19)	Females (n=13)	p-value
		Mean ± SD	Mean ± SD	
Non-modifiable	Age (years)	15.05±1.78	16±2.16	0.185
	HT (cm)**	162.95±6.47	155.14±5.32	0.001
	ST (cm)	85.71±4.03	83.29±2.45	0.064
	AS (cm)*	53.76±2.65	51.75±2.65	0.044
	SD (cm)**	18.09±1.15	16.91±1.13	0.007
	TH (cm)	81.93±6.09	80.02±3.59	0.320
	AB (cm)*	38.59±2.91	36.52±1.88	0.031
	IB (cm)	27.62±2.03	27.58±1.85	0.965
	HB (cm)	5.97±0.61	5.75±0.53	0.313
	FB (cm)	8.92±0.62	8.85±0.69	0.750
Modifiable	DOT (years)	1.99±1.32	2.31±1.86	0.577
	BW (kg)	53.86±7.23	51.17±7.69	0.322
	FFM (kg)**	43.50±4.54	38.15±3.81	0.002
	%BF (%)**	18.73±5.16	24.92±3.91	0.001
	BMI (kg/m^2)	20.20±1.80	21.14±1.82	0.159
	AG (cm)	24.64±1.92	24.92±2.41	0.716
	TG (cm)*	45.22±4.86	49.00±3.98	0.027
	CG (cm)	33.73±1.93	34.84±2.74	0.187
	LG (kg)**	37.16±5.71	29.31±6.25	0.001
	RG (kg)***	39.42±6.62	28.31±5.35	<0.001
	SP (cm)***	309.05±44.97	236.15±23.80	<0.001
	BS (kg)***	63.23±10.03	39.08±11.97	<0.001
	VJ (cm)***	41.58±4.49	34.38±3.50	<0.001
	F (cm)	37.08±4.45	37.46±4.13	0.807

[Table/Fig-1]: Comparison of anthropometric, strength and flexibility parameters among the studied subjects.
*,**and***Significant at p<0.05, <0.01 and <0.001 level. Independent t–test. SD=Standard Deviation.HT: Standing Height, SH: Sitting Height, AS: Acromiale-Stylion Length, SD: Midstylion-Dactylion Length, TH: Trochanterion Height, AB: Biacromial Breadth, IB: Biiliocristal Breadth, HB: Biepicondylar Humerus Breadth, FB: Biepicondylar Femur Breadth, DOT: Duration Of Training, BW: Body Weight, FFM: Fat Free Mass, %BF: Percentage Body Fat, BMI: Body Mass Index, AG: Relaxed Arm Girth, TG: Mid-Thigh Girth, CG: Calf Girth, LG: Left Hand Grip, RG: Right Hand Grip, SP: Seated Shot Put Throw Score, BS: Back Strength, VJ: Vertical Jump Score, and F: Lower Back and Hamstring Flexibility.

Grip strength is an important component in performing various skills involving hockey stick both in practice and competition. The mean grip strength of the studied players was lower than that of South African male players with grip strength of 54±8 kg [33]. After controlling for gender, [Table/Fig-2] shows that the players who were taller with longer trunk and lower limbs, and with broader chest and hip had stronger grip in both the hands. It was also more among the players who were heavier, leaner, and with bulkier arms and lower limbs [Table/Fig-3]. The players who had longer upper limbs had stronger left hand grip [Table/Fig-2]. In both groups of the players, the stronger grip was associated with longer trunk, broader chest, heavier and leaner body with bulkier arm, and interestingly, with more BMI [Table/Fig-2,3].

In field hockey, there is also much importance of upper body strength as it allows the players to shoot and pass the ball more powerfully and over a larger range of distance [13]. The upper limb power, as estimated by seated shot put throw score [20], was found to be more among the players who were taller with more trunk, limb and hand length, and broader chest and hip, after controlling for gender [Table/Fig-2,3]. The players who were heavier, leaner, and with bulkier arms and lower limbs also had stronger upper limbs. In both the groups also, body weight, FFM and BMI were associated positively with upper limb strength [Table/Fig-3].

Back strength, endurance and flexibility are important in field hockey as the field hockey players have to spend much time bending forward to the ground for maximum ground work [11]. After gender was controlled, back strength was found to be more for the taller players

Variables	Gender	LG (kg)	RG (kg)	SP (cm)	BS (kg)	VJ (cm)	F (cm)
Age (years)	Female	0.407	0.296	0.499	0.202	-0.055	0.360
	Male	0.486*	0.517*	0.495*	0.524*	0.427	0.365
	Combined#	0.449*	0.421*	0.462**	0.366*	0.235	0.360*
HT (cm)	Female	0.773**	0.790**	0.552	0.442	0.393	0.170
	Male	0.441	0.438	0.719**	0.480*	0.681**	0.456*
	Combined#	0.560**	0.546**	0.670***	0.458*	0.595***	0.359*
SH (cm)	Female	0.622*	0.650*	0.506	0.467	0.203	0.369
	Male	0.528*	0.579**	0.787**	0.651**	0.622**	0.516*
	Combined#	0.537**	0.592***	0.737***	0.563**	0.518**	0.467**
AS (cm)	Female	0.682*	0.732**	0.481	0.128	0.279	-0.038
	Male	0.121	0.100	0.670**	0.348	0.526*	0.380
	Combined#	0.357*	0.320	0.597***	0.250	0.439*	0.220
SD (cm)	Female	0.580*	0.562*	0.452	0.500	0.700**	0.460
	Male	0.274	0.197	0.355	0.099	0.191	0.256
	Combined#	0.401*	0.322	0.366*	0.361*	0.294	0.333
TH (cm)	Female	0.640*	0.699**	0.391	0.089	0.456	-0.110
	Male	0.315	0.338	0.494*	0.253	0.546*	0.154
	Combined#	0.397*	0.421*	0.476**	0.190	0.521**	0.082
AB (cm)	Female	0.586*	0.651*	0.532	0.294	0.579*	0.219
	Male	0.500*	0.592**	0.606**	0.600**	0.456*	0.293
	Combined#	0.512**	0.605***	0.591***	0.476**	0.486**	0.268
IB (cm)	Female	0.571*	0.459	0.409	0.169	0.485	0.021
	Male	0.453	0.593**	0.578**	0.467*	0.218	0.326
	Combined#	0.498**	0.548**	0.523**	0.338	0.303	0.216
HB (cm)	Female	0.476	0.475	0.215	0.246	0.263	0.548
	Male	0.081	-0.121	0.250	-0.046	0.084	0.195
	Combined#	0.232	0.068	0.236	0.072	0.139	0.318
FB (cm)	Female	0.322	0.393	0.159	-0.046	0.016	-0.049
	Male	0.150	-0.144	0.305	-0.103	0.304	0.152
	Combined#	0.227	0.057	0.250	-0.076	0.196	0.070

[Table/Fig-2]: Correlation of non-modifiable anthropometric variables with strength and flexibility variables among the studied subjects.
*,**and***Significant at p<0.05, <0.01 and <0.001 level. Pearson's zero-order correlation (r-values given); #partial correlation r-values, controlling for gender (n=32, df=29). df=degree of freedom. HT: Standing Height, SH: Sitting Height, AS: Acromiale-Stylion Length, SD: Midstylion-Dactylion Length, TH: Trochanterion Height, AB: Biacromial Breadth, IB: Biiliocristal Breadth, HB: Biepicondylar Humerus Breadth, FB: Biepicondylar Femur Breadth, LG: Left Hand Grip, RG: Right Hand Grip, SP: Seated Shot Put Throw Score, BS: Back Strength, VJ: Vertical Jump Score, and F: Lower Back and Hamstring Flexibility.

Variables	Gender	LG (kg)	RG (kg)	SP (cm)	BS (kg)	VJ (cm)	F (cm)
DOT (years)	Female	0.363	0.217	0.343	0.142	-0.143	0.126
	Male	0.365	0.545*	0.577**	0.521*	0.519*	0.548*
	Combined#	0.361*	0.389*	0.451*	0.320	0.230	0.344
BW (kg)	Female	0.787**	0.816**	0.572*	0.441	0.412	0.035
	Male	0.669**	0.591**	0.847**	0.679**	0.533*	0.622**
	Combined#	0.721***	0.667***	0.736***	0.569**	0.484**	0.388*
FFM (kg)	Female	0.776**	0.827**	0.574*	0.436	0.329	0.149
	Male	0.631**	0.592**	0.756**	0.556*	0.543*	0.435
	Combined#	0.681***	0.665***	0.701***	0.500**	0.478**	0.337
%BF (%)	Female	0.711**	0.715**	0.516	0.401	0.496	-0.156
	Male	0.446	0.359	0.642**	0.610**	0.290	0.633**
	Combined#	0.532**	0.462**	0.609***	0.519**	0.348	0.379*
BMI (kg/m^2)	Female	0.746**	0.790**	0.560*	0.427	0.396	-0.030
	Male	0.624**	0.502*	0.649**	0.610**	0.189	0.528*
	Combined#	0.675***	0.600***	0.601***	0.526**	0.259	0.313
AG (cm)	Female	0.706**	0.755**	0.538	0.308	0.192	-0.021
	Male	0.649**	0.536*	0.688**	0.644**	0.419	0.622**
	Combined#	0.675***	0.610***	0.594***	0.476**	0.321	0.337
TG (cm)	Female	0.571*	0.524	0.418	0.145	0.009	-0.110
	Male	0.502*	0.381	0.671**	0.425	0.295	0.567*
	Combined#	0.523**	0.425*	0.604***	0.309	0.209	0.339
CG (cm)	Female	0.545	0.711**	0.489	0.131	0.023	-0.197
	Male	0.668**	0.448	0.594**	0.512*	0.328	0.384
	Combined#	0.600***	0.541**	0.502**	0.308	0.190	0.109

[Table/Fig-3]: Correlation of modifiable anthropometric variables with strength and flexibility variables among the studied subjects.
*,**and***Significant at p<0.05, <0.01 and <0.001 level. Pearson's zero-order correlation (r-values given); #partial correlation r-values, controlling for gender (n=32, df=29). df=degree of freedom.DOT: Duration Of Training, BW: Body Weight, FFM: Fat Free Mass, %BF: Percentage Body Fat, BMI: Body Mass Index, AG: Relaxed Arm Girth, TG: Mid-Thigh Girth, CG: Calf Girth, LG: Left Hand Grip, RG: Right Hand Grip, SP: Seated Shot Put Throw Score, BS: Back Strength, VJ: Vertical Jump Score, and F: Lower Back and Hamstring Flexibility.

having longer trunk and hand, and with broader chest [Table/Fig-2]. It was also more among the players who were heavier, leaner and having bulkier arms [Table/Fig-3].

Strength quality and explosive power in the lower limb musculature as assessed by the vertical jump test [21-27] was found to be more among the players who were taller with more trunk and limb length, and with broader chest, when the effect of gender was controlled [Table/Fig-2]. Those players who were heavier and leaner also had more lower limb strength (non significant for females) [Table/Fig-3]. In both the gender groups, having broader chest was also associated positively with lower limb strength [Table/Fig-2].

For the lower back and hamstring flexibility, the study showed that those players who were heavier, taller with longer trunk were more flexible, after controlling for gender [Table/Fig-3]. A point to be noted is that those with more %BF were more flexible among the males and when both the groups were analysed as a whole after controlling for gender [Table/Fig-3]. However, among females, those with more BMI and %BF were less flexible, although statistically non significant. Weak significant and non significant positive correlations of flexibility score with BMI and %BF were reported earlier among young male soccer players [34], and adolescent female volleyball players [35].

Also, there was positive correlation between %BF and BMI with most of the strength variables (except for VJ). This finding might be explained, at least in part, by the positive correlation between %BF and BMI with FFM in our study {zero order correlation: (a) %BF and FFM: $r=0.381$, $p=0.108$ (male players); $r=0.840$, $p<0.001$ (female players) (b) BMI and FFM: $r=0.667$, $p=0.002$ (male players); $r=0.938$, $p<0.001$ (female players). Partial correlation, controlling for gender: (a) %BF and FFM, $r= 0.517$, $p=0.003$; (b) BMI and FFM, $r=0.762$, $p<0.001$. Not shown in the result section}. One study did report positive correlation between fat mass and fat free mass over the body fat range of 10 to 90 kg [36]. The finding of higher BMI with higher FFM and lower %BF has also been reported [37,38]. Hence, BMI should be cautiously used for indicating fatness among sports persons [18].

Our study thus showed statistically significant association of anthropometric characteristics over strength variables and flexibility score, which are known not only to have considerable impact over the game of field hockey [1,7,11], but also related to injury risk [39].

LIMITATION

However, due to the cross-sectional nature of the study with non randomly selected small sample size from only one training centre of SAI, further well designed studies with sufficiently large sample size are required.

CONCLUSION

Our result showed that following non-modifiable anthropometric measures may be considered in selection of players for field hockey: standing height, sitting height, biacromial breadth, trochanterion height, acromiale-stylion length, midstylion-dactylion length and biiliocristal breadth. The most important modifiable anthropometric measures were related to body weight (BW) and composition (FFM and %BF), and hence appropriate training should be given to keep them under desirable range. Thus, the finding may be helpful for training monitoring, talent identification and selection of players for field hockey. The present study may also inspire for further large scale studies in the related field.

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