

Correlations of Handgrip Strength with Selected Hand-Arm-Anthropometric Variables in Indian Inter-university Female Volleyball Players

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Abstract

Purpose: The purpose of this study was to estimate the dominant handgrip strength and its correlations with some hand and arm anthropometric variables in 101 randomly selected Indian inter-university female volleyball players aged 18-25 years (mean age 20.52 ± 1.40) from six Indian universities.

Methods: Three anthropometric variables, i.e. height, weight, BMI, two hand anthropometric variables, viz. right and left hand width and length, four arm anthropometric variables, i.e. upper arm length, lower arm length, upper extremity length, upper arm circumference and dominant right and non-dominant handgrip strength were measured among Indian inter-university female volleyball players by standard anthropometric techniques.

Results: The findings of the present study indicated that Indian female volleyball players had higher mean values in eleven variables and lesser mean values in two variables than their control counterparts, showing significant differences ($P < 0.032-0.001$) in height ($t=2.63$), weight ($t=8.66$), left hand width ($t=2.10$), left and right hand length ($t=9.99$ and 10.40 respectively), right upper arm length ($t=8.48$), right forearm length ($t=5.41$), dominant (right) and non-dominant (left) handgrip strength ($t=9.37$ and 6.76 respectively). In female volleyball players, dominant handgrip strength had significantly positive correlations ($P \leq 0.01$) with all the variables studied.

Conclusion: It may be concluded that dominant handgrip strength had strong positive correlations with all the variables studied in Indian inter-university female volleyball players.

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INTRODUCTION

Volleyball is an intermittent sport. It requires players to participate in frequent short bouts of high-intensity exercise, followed by periods of low-intensity activity^[1,2]. The high-intensity bouts of exercise, coupled with the total duration of the match requires players to have well-developed aerobic and

anaerobic alactic (ATP-CP) energy systems^[2,3]. As a result, volleyball players require well-developed speed, agility, upper-body and lower body muscular power, and maximal aerobic power. Several studies have examined the relationships between anthropometric and physiological characteristics of volleyball players^[4,5].

The power of handgrip is the result of forceful flexion of all finger joints with the maximum voluntary

force that the subject is able to exert under normal biokinetic conditions [6,7], which uses several muscles in the hand and the forearm [8]. The estimation of handgrip strength is of immense importance in sports like wrestling, tennis, football, handball, basketball, volleyball, and baseball where a sufficient degree of grip strength is necessary to be successful. For example, without adequate grip and forearm strength, tennis players may run the risk of developing lateral epicondylitis, commonly known as tennis elbow. Often overlooked or taken for granted, the strength of one's grip plays a key role in injury prevention and overall strength development [9-12]. In many cases, strengthening of the grip has been a prescription for rehabilitation from injuries such as golfers and tennis elbow. These ailments are often caused by improper strength ratios between the elbow muscles and the forearm muscles. If the elbow flexors, like the biceps and brachialis are too strong for the forearm flexors, uneven tension accumulates in the soft tissue and results in elbow pain [13]. Recent studies related to handgrip strength and selected arm-anthropometric variables in Indian basketball and volleyball players were also reported [14,15].

Grip strength determines the handedness of an individual, an important field of population variation study. It is often used as an indicator of overall physical strength [16,17], hand and forearm muscle performances [18] and as a functional index of nutritional status [19-28] and physical performance [29,30]. Handgrip strength is a physiological variable that is affected by a number of factors including age, gender and body size.

To the best of our knowledge, the information related to the correlations of hand- and arm-anthropometric variables and grip strength in volleyball players remains largely unreported so far. In fact, handgrip strength has been established as an indicator of the overall body strength of an individual [17]. Strong correlations between handgrip strength and various anthropometric traits, (weight, height, hand length etc.) have also been reported earlier [31-40]. The rationale of conducting the present study was to search for the correlations of handgrip strength with selected hand and arm anthropometric variables to excel the performance of the players as well as to avoid sport-

specific injuries, which was the practical perspective of the study too. The hypothesis of the present study was that Indian female volleyball players would have greater handgrip strength than the controls and grip strength would carry significant correlations with the selected hand and arm anthropometric variables in them.

METHODS AND SUBJECTS

Participants:

The present cross-sectional study is based on 101 randomly selected Indian inter-university female volleyball players aged 18–25 years (mean age 20.52 ± 1.40 years). An adequate number of controls ($n = 100$, mean age 21.10 ± 1.70) with no particular athletic background were also collected from the same place for comparisons. The age of the subjects was recorded from the date of birth registered in their respective institutions. The subjects were divided in such a way that age 18 refers to the individuals aged 17 years and 6 months through 18 years and 5 months and 29 days.

Exclusion criteria were set upon the knowledge of some genetic, psychological, neurological or chronic diseases affecting hand function and anthropometric characteristics [41,42]. A written consent was obtained from the subjects. The data were collected under natural environmental conditions in the morning (between 8 AM. To 12 noon).

Anthropometric Measurements:

Three anthropometric variables, i.e. height (HT), weight (WT) and body mass index (BMI), two hand anthropometric variables, i.e. right and left hand width and length, four arm anthropometric variables, i.e. upper arm length, lower arm length, upper extremity length, upper arm circumference and dominant right and non-dominant left hand grip strength were measured following standard techniques [43] and were measured in triplicate with the median value used as the criterion.

The height was recorded during inspiration 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 $\text{weight (kg)}/\text{height}^2 \text{ (m)}^2$. Hand length and hand width of both sides were measured by Vernier slide caliper (Starrett, 123 Series, U.S.A.). Upper arm length, forearm length, upper extremity length was measured by the first segment of the anthropometer rod and upper arm circumference was measured by steel tape and these measurements were taken on the subject's right side.

Handgrip strength measurement:

The grip strength of both right and left hands was measured using a standard adjustable digital handgrip dynamometer (Takei Scientific Instruments Co., LTD, Japan) at standing position with the shoulder adducted and neutrally rotated and elbow in full extension. The dynamometer was held freely without support, not touching the subject's trunk. The position of the hand remained constant without downward direction. The subjects were asked to put maximum force on the dynamometer thrice from both sides of the hands. The maximum value was recorded in kilograms. Anthropometric equipment and handgrip dynamometer were calibrated before each assessment. All subjects were tested after 3 minutes of independent warm-up. A

thirty seconds time interval was maintained between each handgrip strength testing.

Statistical analysis:

Standard descriptive statistics (mean \pm standard deviation) were determined for directly measured and derived variables. The data showed normal distribution encouraging us to use parametric statistics. Independent t-test was used for comparisons between volleyball players and controls for all the measured variables. Pearson's correlation coefficients were used to establish the correlations of dominant and non-dominant handgrip strength with other variables in volleyball players. Data were analyzed using SPSS (Statistical Package for Social Science) version 17.0. A 5% level of probability was used to indicate statistical significance.

RESULTS

Descriptive statistics of anthropometric characteristics and handgrip strength of Indian inter-university female volleyball players are shown in Table 1. Indian female volleyball players have higher mean values in almost all the variables studied, except right upper extremity

Table 1: Descriptive statistics of hand grip strength and some selected anthropometric characteristics in Indian inter-university female volleyball players

Variables	Volleyball players (n= 101)	Controls (n=100)	P-value
	Mean (SD)	Mean (SD)	
Height (cm)	164.78 (4.00)	159.41 (4.82)	0.03
Body weight (kg)	58.16 (5.54)	53.00 (7.69)	<0.001
Body mass index (kg/m ²)	21.39 (1.58)	20.90 (3.17)	0.2
Right hand width (cm)	7.25 (0.37)	7.20 (0.34)	0.3
Left hand width (cm)	7.19 (0.34)	7.09 (0.33)	0.04
Right hand length (cm)	18.13 (0.80)	17.03 (0.68)	<0.001
Left hand length (cm)	18.08 (0.80)	17.03 (0.67)	<0.001
Right upper arm length (cm)	33.38 (1.88)	31.24 (1.68)	<0.001
Right forearm length (cm)	26.89 (1.53)	25.73 (1.49)	<0.001
Right upper extremity length (cm)	77.32 (3.54)	79.97 (7.27)	0.7
Right upper arm circumference (cm)	25.20 (1.76)	25.43 (2.72)	0.5
Dominant right hand grip strength (kg)	27.04 (2.64)	22.69 (3.82)	<0.001
Non-dominant left hand grip strength (kg)	24.10 (2.66)	20.93 (3.86)	<0.001

SD: Standard Deviation

Table 2: Inter-correlation matrix of hand grip strength and some selected anthropometric variables among Indian inter-university female volleyball players

Variables	WT	BMI	RHW	LHW	RHL	LHL	RUAL	RFAL	RUEL	RUAC	DHGS	NDLHGS
HT	0.66*	0.20 [‡]	0.69*	0.60*	0.57*	0.56*	0.78*	0.66*	0.77*	0.29*	0.49*	0.38*
WT	1	0.87*	0.44*	0.45*	0.63*	0.58*	0.51*	0.52*	0.67*	0.56*	0.57*	0.35*
BMI		1	0.12	0.19	0.44*	0.39*	0.15	0.25*	0.37*	0.54*	0.43*	0.21 [‡]
RHW			1	0.83*	0.41*	0.42*	0.60*	0.60*	0.56*	0.17	0.28*	0.26*
LHW				1	0.46*	0.53*	0.55*	0.59*	0.53*	0.25 [‡]	0.36*	0.29*
RHL					1	0.98*	0.43*	0.52*	0.67*	0.20 [‡]	0.48*	0.35*
LHL						1	0.44*	0.54*	0.66*	0.16	0.48*	0.35*
RUAL							1	0.63*	0.78*	0.35*	0.37*	0.28*
RFAL								1	0.76*	0.17	0.51*	0.41*
RUEL									1	0.27*	0.52*	0.40*
RUAC										1	0.24 [‡]	0.10
DHGS											1	0.76*

[‡] Significant at 0.05 level; * Significant at 0.01 level; HT = Height; WT=Body weight; BMI= Body mass index; RHW= Right hand width; LHW= Left hand width; RHL=Right hand length; LHL= Left hand length; RUAL= Right upper arm length; RFAL= Right forearm length; RUEl= Right upper extremity length; RUAC= Right upper arm circumference; DHGS= Dominant right hand grip; NDLHGS= Non-dominant left hand grip

length and right upper arm circumference than their control counterparts, showing statistically highly significant differences ($P<0.001$) in all the variables except BMI, right hand width, right upper arm extremity and right upper arm circumference.

Bivariate correlations of the anthropometric characteristics and handgrip strength were examined in Indian inter-university volleyball players in Table 2. Dominant hand grip strength had significantly positive correlations ($P\leq 0.01$) with all the variables. Height and

weight too, had significantly positive correlations ($P\leq 0.01$) with all the variables. For the rest of the anthropometric variables, it was observed that almost all the hand and arm anthropometric variables were correlated significantly ($P\leq 0.05-0.01$) with positive correlations to each other.

Table 3 shows the inter-correlation matrix of handgrip strength and some selected anthropometric variables in controls. Among the anthropometric variables and handgrip strength, few significantly

Table 3: Inter-correlation matrix of hand grip strength and some selected anthropometric variables in controls

Variables	WT	BMI	RHW	LHW	RHL	LHL	RUAL	RFAL	RUEL	RUAC	DHGS	NDLHGS
HT	0.15	-0.27*	0.37*	0.45*	0.52*	0.47*	0.65*	0.35*	0.14	-0.05	0.16	0.01
WT	1	0.91*	0.21 [‡]	0.18	0.07	0.01	0.19	0.12	0.18	0.85*	0.22*	0.15
BMI		1	0.05	-0.02	-0.16	-0.20 [‡]	-0.09	-0.04	0.10	0.84*	0.15	0.14
RHW			1	0.81*	0.41*	0.49*	0.39*	0.25 [‡]	0.05	0.10	0.43*	0.38*
LHW				1	0.39*	0.47*	0.45*	0.23 [‡]	0.08	0.10	0.31*	0.21 [‡]
RHL					1	0.94*	0.45*	0.39	0.03	0.00	0.18	0.04
LHL						1	0.43*	0.31*	0.09	-0.04	0.22 [‡]	0.10
RUAL							1	0.25 [‡]	0.02	0.11	0.16	0.00
RFAL								1	0.04	0.02	0.19	0.04
RUEL									1	0.21 [‡]	0.15	0.21
RUAC										1	0.11	0.08
DHGS											1	0.81*

[‡] Significant at 0.05 level; * Significant at 0.01 level; HT = Height; WT=Body weight; BMI= Body mass index; RHW= Right hand width; LHW= Left hand width; RHL=Right hand length; LHL= Left hand length; RUAL= Right upper arm length; RFAL= Right forearm length; RUEl= Right upper extremity length; RUAC= Right upper arm circumference; DHGS= Dominant right hand grip; NDLHGS= Non-dominant left hand grip

positive correlations were noted. All the measurements were taken by JS and the inter-tester variability was also tested.

DISCUSSION

Anthropometric dimensions and morphological characteristics play an important role in determining the success of an athlete [44-46]. Quite naturally, the interest in anthropometric characteristics and body composition of athletes from different competitive sports has increased tremendously over the last decades. All ball games require comprehensive abilities including physical, technical, mental and tactical ones. Among them, physical abilities of the players are more important as these have marked effects on the skill of players and the tactics of the teams because ball games require repeated maximum exertion such as dashing and jumping [47].

In volleyball, teams compete by manicores handling the ball above the head, height is considered to be the most important physical attribute. In the present study, the Indian female volleyball players have higher mean values in all the variables, except right upper extremity length and right upper arm circumference than their control counterparts. These differences were, might be, due to the effect of regular physical exercise and training of the players. When comparisons were made between Indian female volleyball players and their foreign counterparts, Indian female players had lesser mean values for height and weight (164.78 cm, \pm 4.00 and 58.16 kg \pm 4.54 respectively) than the American (176.70 cm, \pm 4.60 and 69.70 kg \pm 10.80 respectively) [48] and Turkish (174.00 cm, \pm 7.60 and 61.1 kg \pm 8.70 respectively) [49] female volleyball players. These differences were, might be, due to the level of competitions the players participated. In the study, significantly greater height to body weight ratio (H/W = 2.83) among the Indian inter-university female volleyball players might be disadvantageous for them in attaining a good jumping height as they have to lift a greater weight.

In case of relationships of handgrip strength, a physical performance indicator, with height, weight, BMI and two hand- and four arm anthropometric characteristics, strong correlations were found. It was earlier reported too that handgrip strength had strong correlations with various anthropometric characteristics [14,15,49-52] and males attained stronger handgrip than their female counterparts [46]. Right and left hand grip strength was positively correlated with weight, height and body surface area [53]. The findings of the present study followed the same line showing strong positive correlations with dominant right and non-dominant left handgrip strength and all the hand-arm anthropometric variables studied.

The limitations of the study were that, firstly, male data could have also been incorporated to draw a generalized statement, and, secondly, national level players could have been taken into account to validate these correlations. The future scope of the study is immense. To search the talents in sport, to organize the gender-specific training program, to avoid sports-specific injuries and finally to improve the performance of the players the findings of the present study carried immense practical implications.

CONCLUSION

It may be concluded that dominant handgrip strength had some strong positive correlations with all the variables studied in Indian inter-university female volleyball players. The data presented in the present study carry immense practical application and may be useful in future investigation on player selection, talent identification in volleyball and training program development.

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