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Correlations of dominant handgrip strength with selected anthropometric and physiological characteristics in inter-university volleyball players

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Abstract: *The purpose of the present study was to estimate the dominant handgrip strength and its correlations with selected anthropometric and physiological characteristics in inter-university volleyball players. Three anthropometric characteristics, four body composition parameters, two physical and two physiological characteristics were measured on randomly selected 63 inter-university volleyball players (38 males and 25 females) aged 18–25 years from six Indian universities, competition was held in Guru Nanak Dev University, Amritsar, Punjab, India. An adequate number of controls (n = 102, 52 males and 50 females) were also taken from the same place for comparisons. In results, one way analysis of variance showed significant ($p \leq .004$ - $.000$) differences in all the variables between volleyball players and controls. In volley players, significantly positive correlations were found between right and left handgrip strength and all the variables studied except percent body fat (where the correlations were significantly negative). It may be concluded that dominant handgrip strength had some strong positive correlations with all the variables studied in inter-university volleyball players.*

Keywords: Anthropometric characteristics. Handgrip strength.VO_2 max.Inter-university volleyball players.

Introduction

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 (Richards et al. 1996, Bohannon 1997) which uses several muscles in the hand and the forearm (Bassey and Harrie 1993). Grip strength is often used as an indicator of overall physical strength (Massey-Westrop et al. 2004, Foo 2007), hand and forearm muscles performances (Nwuga 1975) and as a functional index of

nutritional status (Chilima and Ismail 2001,Pieterse et al. 2002) and physical performance (Samson et al. 2000,Onder et al. 2002).

Handgrip strength is a physiological variable that is affected by a number of factors including age, gender and body size. Strong correlations between grip strength and various anthropometric traits, (weight, height, hand length etc.) were reported earlier (Malina et al. 1987,Ross and Rösblad 2002, Singh et al. 2009,Koley and Yadav 2009,Koley and Singh 2009,Koley et al. 2009,Jurimae et al. 2009,Kaur 2009).

Several studies have examined the relationships between anthropometric and physiological characteristics of volleyball players (Fleck et al. 1985, Fry et al. 1991). But information related to the correlations of handgrip strength and anthropometric characteristics in volleyball players are limited, especially in Indian context. So the present study was planned.

Materials and Methodology

Participants

The present cross-sectional study is based on randomly selected 63 inter-university volleyball players (38 males and 25 females) aged 18–25 years (mean 19.05 years, ± 1.40) from Punjabi University, Patiala, Punjab University, Chandigarh, Guru Nanak Dev University, Amritsar, Kurukshetra University, Kurukshetra, Himachal Pradesh University, Himachal Pradesh and Delhi University, Delhi, and the competition was organized in Guru Nanak Dev University, Amritsar, Punjab, India. An adequate number of controls (n = 102, 52 males and 50 females, mean age 21.60 years, ± 2.13) with no particular athletic background were also collected from the same place for comparisons. The age of the subjects were recorded from the date of birth registered in their respective institutes. 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. A written consent was obtained from the subjects. The data were collected under natural environmental conditions in morning (between 8 AM. to 12 noon). The study was approved by the local ethics committee.

Measurements and calculations

Three anthropometric variables, viz. height (HT), weight (WT) and BMI, four body composition parameters, viz. percent body fat (%BF), percent lean body mass (%LBM), basal metabolic rate (BMR) and water percent (%W), two physical parameters, viz. right and left hand grip strength (RHGS and LHGS respectively) and two physiological variables, viz. heart rate (HR) and VO_2 max (VO_2M) were measured on each subject. Anthropometric variables of the subjects were measured using the techniques provided by Lohmann et al. (1988) 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 weight (kg)/height^2 (m)^2. Percent body fat was assessed using skinfold measurements taken from four sites, viz. biceps, triceps, subscapular and suprailiac using Harpenden skinfold caliper (Holtain Ltd, Crosswell, Crymych, UK) to the nearest 0.2 mm, and using the Durnin and Womersley (1974) skinfold equation. Percent lean body mass was calculated subtracting percent body fat from 100. Basal metabolic rate and water percent were assessed by Bioelectrical Impedance Analysis (Houtkooper et al. 1996). Heart rate was estimated manually immediately after step test. VO_2 max was estimated by Queen's College Step Test (McArdle et al. 1972).

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 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 the 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. Thirty seconds time interval was maintained between each handgrip strength testing.

Statistical analysis

Standard descriptive statistics (mean ± standard deviation) were determined for directly measured and derived variables. One way analysis of variance was tested for the comparisons of data among inter-university volleyball players and controls, followed by post hoc Bonferroni test. Pearson's correlation coefficients were applied to establish the relationships among the variables measured. 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 selected anthropometric, body compositional, physical and physiological characteristics in inter-university volleyball players and controls were shown in Table 1. In volleyball players, significant sex differences ($p \leq .01$) were noted in all the variables studied, except BMI and heart rate. When male volleyball players were compared with their control counterparts, statistically significant differences ($p \leq .05$ - .01) were found in all the variables studied, but surprisingly, female

volleyball players had significant differences ($p \leq .01$) only in heart rate and VO_2 max with their control counterparts.

Bivariate correlations of the anthropometric traits were examined in inter-university volleyball players in Table 2. Right and left handgrip strength had significantly positive correlations ($p \leq .01$) with all the variables except heart rate. Among the other

variables, height and weight had the significantly positive correlations with almost all the variables. Percent body fat had significantly negative correlations ($p \leq .01$) with almost all the variables except heart rate. On the other hand, VO_2 max had significantly positive correlations ($p \leq .01$) with almost all the variables (except heart rate).

Table1. Descriptive statistics of selected anthropometric and physiological characteristics in inter-university volleyball players

	Volleyball players (n=63)				Controls (n=102)			
Variables	males		females		males		females	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
HT (cm) *	181.93	6.37	159.67	5.85	170.62	5.88	159.17	6.05
WT (kg) *	69.09	69.09	49.96	7.51	64.38	11.03	51.83	8.97
BMI (kg/m^2) **	20.66	2.46	19.62	2.79	22.15	3.56	20.46	3.80
%BF *	13.48	2.91	20.40	2.92	18.75	5.21	21.88	4.45
%LBM *	86.52	2.91	79.60	2.92	81.26	5.21	78.12	4.45
% W *	61.74	3.76	56.72	3.84	54.89	4.49	49.72	7.02
BMR (kcal) *	1783.58	161.31	1326.16	82.33	1159.98	8.14	1352.92	106.23
HR (beats/min)*	99.05	2.72	101.60	6.11	119.31	13.32	123.20	12.07
VO_2M(ml/kg/min*	69.73	3.82	47.04	1.13	61.22	5.59	43.04	2.22
RHGS (kg)*	43.66	5.88	24.21	3.64	41.11	6.57	21.25	4.24
LHGS (kg)*	42.33	6.17	23.60	4.44	38.62	6.40	20.45	4.18

* Significant at 0.05 level; ** significant at .01; HT = Height; WT = Weight< BMI = Body mass index; %BF = Percent body fat; %LBM = Percent lean body mass; % W = Water percent; BMR = Basal metabolic rate; HR = Heart rate; VO_2 M = VO_2 max; RHGS = Right handgrip strength; LHGS = Left handgrip strength.

Table 2. Inter-correlation matrix of dominant handgrip strength and selected anthropometric characteristics in inter-university volleyball players

Variabl-es	WT	BMI	%BF	%LBM	%W	BMR	HR	VO2M	RHGS	LHGS
HT	.82**	.20	-.58**	.58**	.53**	.91**	-.09	.83**	.85**	.88**
WT		.70**	-.28*	.28*	.32*	.94**	-.05	.68**	.76**	.80**
BMI			.24	-.24	-.18	.51**	.05	.17	.29*	.30*
%BF				-.98**	-.47**	-.46**	.11	-.74**	-.61**	-.59**
%LBM					.47**	.46**	-.11	.74**	.61**	.59**
%W						.47**	-.14	.74**	.50**	.52**
BMR							-.09	.82**	.86**	.89**
HR								-40**	-.12	-.15
VO_2 M									.84**	.84**
RHGS										.96**

* Significant at 0.05 level; ** significant at .01 level.

Discussion

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 (Kunstlinger et al. 1987,Viitasalo et al. 1987). 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 (Polglaze and Dawson 1992,Viitasalo et al. 1987). As a result, volleyball players require well-developed speed, agility, upper-body and lower body muscular power, and maximal aerobic power (VO_2 max).

In volleyball, teams compete by manicures handling the ball above the head, height is considered to be the most important physical attribute. In the present study, the mean height of the male players (181.93 cm, ± 6.37) was greater than the male volleyball players of West Bengal, India (173.10 cm ± 4.19) reported by Bandyopadhyay (2007), but lesser than the English (191.00 cm ± 5.0) (Duncan et al. 2006), while in female players, the mean height (159.67 cm, ± 5.85) was lesser than the American (176.70 cm, ± 4.60) (Ferris et al. 1995) and Japanese (168.70 cm, ± 5.89) (Tsunawake et al. 2003) female volleyball players. In the study, significantly greater body weight among 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 stature, weight, arm and calf circumferences and various subcutaneous skinfolds, it was found that males attained greater values for those anthropometric variables and also had greater handgrip strength values than their female counterparts (Benefice and Malina 1996,Koley et al. 2009, 2010). Right and left handgrip strength was positively correlated with weight, height and body surface area (Chatterjee and Chowdhuri 1991). The findings of the present study followed the same line showing strong positive correlations with dominant right handgrip strength and all the variables studied (except heart rate).

Body composition greatly affects the energy-related physical strength and skill in various sports (Kitagawa et al. 1974). In volleyball players, the estimated % body fat was lower and % LBM and water % was reported to be higher than controls in both sexes, and followed the findings of Tsunawake et al. (1995) and Filaire et al. (1998). These differences between players and controls in the variables studied might be due to regular physical exercise and prolonged training effect. It was found too, that age dependent increase of handgrip strength in males and females as well as inter-gender differences were strongly associated with changes of fat free mass during their childhood (Sartorio et al. 2002). Handgrip strength is found to be a significant determinant of bone mineral content and bone area at the forearm sites and has a positive correlation with lean body mass and physical activity. Hip/waist circumferences measurement is a good marker of fat mass, bone mineral content and lean mass which are strongly correlated with maximum isometric grip force (Rashid and Ahmed 2006).

The findings of the present study also showed very strong positive correlations between dominant handgrip strength and VO_2 max, establishing close association between physical and physiological characteristics in volleyball players. The results followed the findings of Beunen et al. (1992).

The limitations of the study were the less sample size and consideration of players only from inter-university level competitions. In future studies, all these limitations would be taken care.

Conclusions

The data presented in the present study carry immense practical application and should be useful in future investigation on player selection, talent identification in volleyball and training program development.

References

Bassey EJ, Harries UJ. 1993. Normal values for hand grip strength in 920 men and women aged over 65 years and longitudinal changes over 4 years in 620 survivors. *ClinSci* **84**: 331-337.

Benefice E, Malina R. 1996. Body size, body composition and motor performances of mild-to-moderately undernourished Senegalese children. *Ann Hum Bio* **23**: 307-321.

Beunen GP, Malina RM, Renson R, Simons J, Ostyn M,Lefevre J. 1992. Physical activity and growth, maturation and performance: a longitudinal study. *Medicine and Science in Sports and Exercise* **24**: 576-585.

Bohannon RW. 1997. Reference values for extremity muscle strength obtained by handheld dynamometer from adults aged 20 to 79 years. *Arch Phys Med Rehab* **78**: 26 – 32.

Bandyopadhyay A. 2007. Anthropometry and body composition in soccer and volleyball players in West Bengal, India. *Journal of Physical Anthropology* **26(4):** 501-505.

Chatterjee S,Chowdhuri BJ. 1991. Comparison of grip strength and isometric endurance between the right and left hands of men and their relationship with age and other physical parameters. *J Hum Ergo* **20**: 41-50.

Chilima DM, Ismail SJ. 2001. Nutrition and hand grip strength of older adults in rural Malawi. *Public Health Nutr* **9**: 11-17.

Duncan MJ, Woodfield L, Al-Nakeeb Y. 2006. Anthropometric and Physiological characteristics of junior elite volleyball players. *British Journal of Sports Medicine***40**: 649-651.

Durnin JVGA,Womersley J. 1974. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. *British Journal of Nutrition* **32**: 77-97.

Ferris DP, Signorile F, Caruso JF. 1995. The relationship between physical and physiological variables and volleyball spiking velocity. *Journal of Strength and Conditioning Research***9(1)**: 32-36.

Filaire E, Duche P, Lac G. 1998. Effects of training for two balls on the saliva response of adrenocortical hormones to exercise in elite sportswomen.*European Journal of Applied Physiology***77**: 452– 456.

Fleck S, Case S, Puhl J, Van-Handle P. 1985. Physical and physiological characteristics of elite women volleyball players.*Canadian Journal of Applied Sport Science* **10**: 122-126.

Foo LH. 2007.Influence of body composition, muscle strength, diet and physical activity on total body and forearm bone mass in Chinese adolescent girls**.** *Br J Nutr***98**: 1281-1287.

Fry AC, Kraemer WJ, Weseman CA, Conroy BP, Gordon SE, Hoffman JR,Maresh CM. 1991. The effects of an off-season strength and conditioning program on starters and non-starters in women's intercollegiate volleyball. *Journal of Applied Sport Science Research***5**:174-181.

Houtkooper BL, Tomthy GL, Scott BG, Wanda HH. 1996. Why bioelectric impedance analysis should be used for estimating adiposity. *American Journal of Clinical Nutrition* **64**: 436-448.

Jurimae T, Hurbo J,Jurimae J. 2009. Relationship of handgrip strength with anthropometric and body composition variables in prepubertal children. *J Copmar Hum Biol***60**: 225-238.

Kaur M. 2009. Age-related changes in hand grip strength among rural and urban Haryanvi Jat females. *J Copmar Hum Biol* **60**: 441-450.

Koley S, Singh AP. 2009. An association of dominant hand grip strength with some anthropometric variables in Indian collegiate population. *Anthropol Anz* **67**: 21-28.

Koley S, Yadav MK. 2009. An association of hand grip strength with some anthropometric variables in Indian cricket players. *FACTA UNIVERSITATIS, Series: Physical Education and Sports* **7(2)**: 113-123.

Koley S, Kaur N,Sandhu JS. 2009. Association of hand grip strength and some anthropometric traits in female labourers of Jalandhar, Punjab, India. *J Life Sci* **1**: 57-62.

Kunstlinger U, Ludwig HG, Stegemann J. 1987. Metabolic changes during volleyball matches. *International Journal of Sports Medicine***8**: 315 – 322.

LohmannTG, Roche AF,Martorell R. 1988. *Anthropometric Standardization Reference Manual.* Champaign, IL: Human Kinetics Books.

Malina RM, Zavaleta AN, Little BB. 1987. Body size, fatness, and leanness of Mexican American children in Brownsville, Texas: changes between 1972 and 1983. *Am J Public Health***77**: 573-577.

Massey-Westrop N, Rankin W, Ahern M, Krishnan J, Hearn TC. 2004. Measuring grip strength in normal adult: reference ranges and a comparison of electronic and hydraulic instruments. *J Hand Surg***29A**: 514-519.

Mcardle WD, Katch FL,Pechar GS. 1972. Reliability and interrelationship between maximal oxygen intake, physical work capacity and step test scores in college women. *Med Sci Sports Exerc***4**: 182-186.

Nwuga V. 1975. Grip strength and grip endurance in physical therapy students. *Arch Phys Med Rehab***56**: 296-299.

Onder G, Penninx BW, Lapuerta P, Fried LP, Ostir GV, Guralnik JM,Pahor M. 2002. Changes in physical performance over time in older women: the women's Health and Aging Study.*JGeronol A BiolSci Med Sci***57**: M289-M293.

Pieterse S, Manandhar M, Ismail S. 2002. The association between nutritional status and hand grip strength in older Rwandan refugees. *Eur J ClinNutr***56**: 933-939.

Polglaze T, Dawson B. 1992. The physiological requirements of the positions in state league volleyball. *Sports Coach***15**: 32 – 37.

Rashid R, Ahmed SF. 2006. Assessment of bone health and body composition in Glasgow school children.European Congress of Endocrinology. Abstract (No. 11) pp. 35.

Richards L, Olson B,Palmiter-Thomas P. 1996. How forearm position affects grip strength. *Am J OccupTherap***50**: 133 – 139.

Ross CH,Rösblad B. 2002. Norms for grip strength in children aged 4–16 years. *ActaPaediatrica***91**: 617-625.

Samson MM, Meeuwsen IB, Crowe A, Dessens JA, Duursma SA,Verhaar HJ. 2000. Relationships between physical performance measures, age, height and body weight in healthy adults. *Age and Ageing***29**: 235-242.

Sartorio A, Lafortuna CL, Pogliaghi S,Trecate L. 2002.The impact of gender, body dimension and body composition on hand-grip strength in healthy children.*J Endocrinol Invest* **25**: 431-435.

Singh AP, Koley S,Sandhu JS. 2009. Association of hand grip strength with some anthropometric traits in collegiate population of Amritsar. *Orient Anthropol***9**: 99-110.

Tsunawake,N, Tahra Y, Yukawa K, Katsura T, Harada H, Kikuchi Y. 1995. Characteristics of body shape of female athletes based on factor analysis. *App Human Sci***14**: 55-61.

Tsunawake N, Yasuaki T, Kazuhiko M, Satoshi M, Kengo M, Koichi Y. 2003.Body Composition and Physical Fitness of Female Volleyball and Basketball Players of the Japan Inter-high School Championship Teams.*J PhysiolAnthropolAppl Human Sci***22 (4)**: 195–201.

Viitasalo J, Rusko H, Pajala O, Rahkila P, Ahila M,Montonen H. 1987. Endurance requirements in volleyball.*Canadian Journal of Applied Sports Sciences***12**: 194 – 201.