PREDICTING HANDGRIP STRENGTH BASED ON SOME ANTHROPOMETRIC MEASURES, HAND VOLUME, AND HANDPRINT AREA

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Abstract

This study aimed at building a predictive equation for the dominant handgrip strength using some anthropometric measurements, hand volume, and handprint area for physical education students. The sample of this descriptive study was composed of (281)males. The following variables were measured: height, weight, body mass index, hand volume, handprint area, wrist and forearm and upper arm circumference, and handgrip strength) for the dominant hand for male students. The study showed that the most variables that contribute effectively and statistically significantly to the handgrip strength were hand volume, weight, and forearm circumference. Eventually, the predictive equations for the handgrip strength are presented.

Key words*: predictive equation, handgrip strength, anthropometrics, hand volume, handprint area*

Introduction

Anthropometric measurements are important for sports. Each sporting activity requires a certain physical pattern and specific physical features (Mahjoub, 2002). The significant of anthropometric measurements can be summarized in that they are considered a crucial factor when selecting the children for sportive specialties. (Sa'eed, 2008). Bisatti (1998) said that there are high correlations between physical abilities and anthropometric measurements within the performance levels of various sporting activities. Also, referred to the importance of anthropometric measurements for functional variables. Whereas Camliguney, Yilmaz, Soykan, Kekec, Tanis and Ramazanoglu (2012) said that there were differences in physical abilities and anthropometric measurements among the private and governmental schools' students aging (7-11) years old. Kostič, Đurašković, Pantelić, Živković, Uzunović and Živković (2009) mentioned that there is a relationship between anthropometric measurements and coordination skills among boys and girls. Therefore, it is important for coaches and supervisors, while selecting athletes, to consider the anthropometric and physical specifications (Sa'eed, 2008). Hassaneen (1996) focused on the existence of a direct correlation between height, weight and handgrip strength. And demonstrated that athletes of some sports are distinguished from their peers in many body parameters such as the length of the trunk, the width of the shoulders and the narrow pelvis. Michiko, Myoko, Naoko and Toshio (1999); Al Yasery and Al Taiy (2008) referred to the importance of handgrip strength in public life in general and in sporting domain in particular where handgrip strength is one of the components of both health and athletic fitness. Grip strength is important to perform adequately the daily tasks that require grasping objects such as carrying laundry, turning a doorknob, vacuuming, and opening jars, cans etc (Sallis, Prochaska & Taylor, 2000; Alsheshany, Al Khalaf & Khasawneh, 2006).

In athletics many sporting activities require high level of grip strength: weight lifting, wrestling, gymnastic, handball and throwing activates are examples of sports that demand strong grip strength for high level performance. Further, wheelchair athletes depend heavily on grip strength to perform their daily and sport activities (Adams, 1990). Smith, Marten, Henry, Sweek and Bryant (2006) correlated the handgrip and overall body strength and found a direct correlation in handgrip strength and overall body strength in very old subjects. While Fry, Ciroslan, Fry, Leroux, Schilling and Chiu (2006) found a significant correlation between handgrip strength and performance in weight lifters. Several studies within the domain of industrial engineering referred to the importance of handgrip strength in performing many specific movements in different careers which used handgrip (Zatsiorky & Latish, 2001; Moore, Krajewski & Steiner, 2011; NIOSH, 2006). Thus, the current study is considered important for identifying the relationship between the anthropometric measurements and the handgrip strength for its great importance in predicting the handgrip strength level, which is considered an important measure for succeeding in different sporting activities, through which we can anticipate a great sporting future depending on these measurements and specifications.

Given the importance of the handgrip strength, this study has been conducted to identify the most important anthropometric measurements contributing to the handgrip strength, and the most effective ones in accomplishing it since it is considered an effective element in some sporting events which use the hand widely.

Statement of the problem

The anthropometric measurements have a large impact on performance. Each sporting activity has its own anthropometric specifications.

Also, the physical abilities, specifically the maximum strength represented by the handgrip strength, have a large importance for accomplishing several sporting activities, and they have been addressed by several studies regarding how to develop, improve and measure them using the traditional way either through the dynamometer or through using free weights and the tests of static and dynamic maximum strength.

The importance of the study is in finding a new way to measure the handgrip strength through taking into consideration the importance of variables which effectively contribute to the strength of the handgrip such weight, height, the volume of the hand, the handprint area, the circumference of the wrist and forearm and upper arm, as well as identifying their impact on the variable of handgrip's strength, in addition to developing measurement means through concluding a predictive equation for anticipating the handgrip's strength through identifying the variables that mostly contribute to it.

The objectives of the study

Identifying the independent variables under study include: weight, height, body mass index, hand volume, handprint area, circumference of the wrist, forearm and upper arm that mostly contribute to handgrip's strength for dominate hand among male students, and building its own predictive equation.

Methods

Study design: the descriptive approach with its survey method was utilized to conduct this study.

The sample: the sample was selected from the students of the Faculty of physical education at the Hashemite University, with total of (281) male students who accepted to participate in this study. All participants were informed about the risks and benefits of the study and signed an IRB approved informed consent. The study sample represented (51.95%) of the study population.

The research tools

The tests and measurements were used to measure the variables of the study, and the following measurements were conducted: 1) Measuring the height and weight using the Restameter: The person being tested is asked to take off shoes and stay in his light sporting clothes (the shorts and shirt). Then, he is asked to stand up straight on the device, facing it, so as to measure weight in (Kgs). After that, he is asked to put his back the device to measure his height, noting that the body should stay straight up without curves or raising feet or head upward, and the height is recorded by the closest (Cm); 2) Measuring the body mass index (Quitlet index): The Quitlet index is measured through the equation that indicates that the index = (weight (kg) / square of height (m)) (Waldo, 1996); 3) Measuring the handgrip volume using the method of immersing hand in water (Hand volumetric displacement method): Water container conation's valve in the above, fills by water to the end of valve. Under the external vent valve there is a numbered cylinder that measures the level of water to the nearest (Mlg). The hand immersed vertically in water to the end of ulna and radius bone as a landmark noting that it is important not to move hand in water. So then water starts to go into the valve to the tank, the displaced water is the volume of the hand. Displaced water by individual collected in measuring cylinder to the nearest (1Cc) (1Mlg). (Luttgens & Katharine, 1976); 4) Measuring hand span size using the modeling method in(Cm^2): After painting hand and fingers with a colorful material (Mercurochrome & alcohol), the examinee opens his hand to the maximum (hand span) and prints his open hand on a white sheet of paper.

This handprint is divided into square and 5 rectangles, where the square represents the hand palm and the 5 rectangles represent each fingers. Then, the area of the square and the areas of the rectangles are extracted to calculate the area of the hand span through adding the area of the square to the area of the five rectangles, and the result represents the approximate area of the hand print, recording it in (Cm^2) (Plagenhoef, 1971); 5) Measuring the circumferences of wrist, forearm and upper arm using the measuring tape: The measuring tape is wrapped around the wrist on the area of ulna and radius bone, whereas for the forearm, measurement is conducted while the forearm is outstretched downwards in order to record the largest perimeter from the center, as well as for the upper arm. These records are read in (Cm) (Gowitzke & Milner, 1980); 6) Measuring the handgrip strength using the dynamometer: Standing up, the hand grip size adjusted to a position that is comfortable for the individual. The individual stand erect, arms at the sides. The dynamometer is held parallel to the side. The individual squeezes the dynamometer as hard as possible without moving the arm. The examinee is given 3 trials, and then the best one is recorded in (KGS) (Heyward, 2004).

Procedures

Procedures included: 1) The researchers coordinated with the faculty and the university administration so as to get official permissions for executing and conducting the tests and measurements needed for the study; 2) Getting the assistance of a team consisting of master and doctoral students who are qualified in the faculty of physical education, as well as the employees and labs' supervisors; 3) Identifying the tests and measurements; 4) Through the researchers' personal experience in this domain, and after reviewing the previous studies and the related literature, a number of variables were identified that could play an effective role from their own point of view, and directly affect performance regarding the handgrip's strength.

Then, these measurements were revised by 5 qualified experts in this domain, and the results showed that all measurements suggested by the researchers were significant and affective; 5) After identifying the variables, methods for measuring them were selected; 6) The pilot study was conducted: The pilot study was conducted using a sample of (15) students from the faculty on 22nd, of October, 2014 with the aim of identifying the following: a) The validity and accuracy of tools and equipments; b) The readiness and competence of the assisting team; c) The sample understanding level of the tests and measurements; and d) Achieving the scientific conditions for the tests and measurements.

The main experiment was conducted between (28/10/2014- 6/11/2014) in the faculty laboratory at the Hashemite University, with the assistance of the work team. *Data analysis* To achieve the objective of the study linear regression analysis with stepwise method was used.

Results and Discussion

To achieve the objectives of the study which refer to identifying the most contributing independent variables to the variable of dominant handgrip strength, the linear regression analysis was used, and tables (1-5) clarify that.

Table 1 Descriptive Statistics of the variables for male students

	Mean	Std. Dev	Skew
Height (Cm)	173.37	6.86	-0.03
Weight (Kg)	71.11	11.69	0.46
BMI (Kg/m^2)	23.63	3.48	0.50
Hand Volume(Cc^3)	373.83	71.41	0.10
Handprints Area (Cm^2)	142.03	17.33	-0.25
Wrist Circumference (Cm)	17.31	1.45	-0.04
Forearm Circumf. (Cm)	26.38	2.67	0.20
Arm Circumference (Cm)	29.93	4.20	0.43
Hand Grip Strength (Kg)	47.69	8.43	0.26

Table 2 Correlations between variables for male students

	(HT)	(WT)	BMI	(HV)	(HA)	(WC)	(FC)	(AC)	(GS)
Height (HT) (Cm)	1.00	.42**	-.03	.36**	.36**	.24**	.16*	.03	.34**
Weight (WT) (Kg)		1.00	.88**	.56**	.43**	.68**	.45**	.596**	.55**
BMI (Kg/m^2)			1.00	.43**	.29**	.64**	.42**	.64**	.44**
Hand Volume (HV) (Cc^3)				1.00	.55**	.42**	.29**	.38**	.59**
Handprints Area (HA) (Cm^2)					1.00	.39**	.17**	.21**	.37**
Wrist Circumference (WC) (Cm)						1.00	.61**	.54**	.39**
Forearm Circumference (FC) (Cm)							1.00	.48*	.35**
Arm Circumference (AC) (Cm)								1.00	.42**
Hand Grip Strength (GS) (Kg)									1.00

** Significant at the level (p<0.01), * Significant at the level (p<0.05)

Table 3 Model Summary for male results to the dominant hand

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.59a	.35	.35	6.82	.35	148.74	1	279	.000
2	.65b	.42	.42	6.45	.07	34.25	1	278	.000
3	.66c	.43	.42	6.41	.01	4.48	1	277	.035

a. Predictors: (Constant), Hand Grip Volume; b. Predictors: (Constant), Hand Grip Volume, Weight; c. Predictors: (Constant), Hand Grip Volume, Weight, Forearm Circumference

Table 4 ANOVA for male results to the dominant hand

ANOVA						
Model		Sum of Squares	df	Mean Square	F	Sig.
3	Regression	8526.49	3	2842.16	69.24	.000c
	Residual	11371.07	277	41.05		
	Total	19897.56	280			
a. Predictors: (Constant), Hand Grip Volume						
b. Predictors: (Constant), Hand Grip Volume, Weight						
c. Predictors: (Constant), Hand Grip Volume, Weight, Forearm Circumference						
d. Dependent Variable: Hand Grip Strength						

Table 1 shows the means, standard deviations and coefficient skewness for the variables under study (height, weight, body mass index, hand volume, handprint area, wrist circumference, forearm circumference, upper arm circumference, and handgrip's strength) for the dominant hand for male students. It is clear in the table that all means values are higher than standard deviations as well as the values of coefficient skewness which range from (±1) and that indicates the sample's homogeneity within these variables, and its validity to access the regression equation. Table 2 shows the correlation coefficients between the variable of the study and the variable of handgrip's strength for sample, where the correlation matrix reveals the existence of statistically significant correlations between all of the independent variables and the variable of handgrip's strength among the samples, and that indicates the possibility of using these variables for predicting the variable of handgrip's strength.

Tables 3 and 4 show that the value of correlation coefficient among the males sample between the variable of handgrip's strength for the dominant hand and the independent variables (hand volume, weight, forearm circumference) which got access to the regression equation was (0.655). Also, the value of (R Square) which refers to the total contribution percentage was (0.429). It is also clear in the table the value of (adjusted R square) which refers to the percentage of independent variables' contribution to explaining the variance of the handgrip's strength, which reached (0.422), and that is a high percentage with a statistical significance, since (f) value was (69.23) with a significance level of (0.001).

Table 5 Coefficients for male variables to the dominant hand

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
3	(Constant)	6.71	3.92		1.71	.039
	Hand Volume	.05	.01	.40	7.32	.000
	Weight	.20	.04	.28	4.74	.000
	Forearm Circ.	.34	.16	.11	2.12	.035

a. Dependent Variable: Hand Grip strength

Table 5 shows the coefficients, and it is clear that the variables (hand volume, weight and forearm circumference) which got access into the regression equation are only the ones which contributed effectively and statistically significantly to explaining the change in the value of dominant handgrip's strength variable for the male sample participants. The variable of hand's volume got the highest contribution, which percentage was (0.402), then came the weight variable whose contribution percentage was (0.279), followed by the variable of forearm circumference, whose contribution percentage reached (0.108). All of these percentages were statistically significant because their significance level was (0.001, 0.001, 0.035) respectively. This can be explained that the large muscles ordinary have a greater ability to increase size and absolute strength than smaller muscles. In other words, a forearm and handgrip muscles may improve its relative strength by (7% percent), the same as large muscles and this factor is depended on muscle cross- sectional (smith et.al, 2006). Thus, whenever the volume of the hand increased the strength of hand will increase. Strength in general is related to body weight when lean body mass (LBM) is more than fat mass (FM), male in general have more (LBM) and less (FM) compared to females. Yet, heavier females will perform better than light – weight females in strength tests. Forearm circumference is proportional to the size of forearm muscles which in turn depends on the daily use of these muscles. Males in general perform more muscles tasks in daily living compared to female and are more prone to weight training compared to female (Benefice & Ndiaye, 2006). Thus, the regression equation for predicting the strength of the dominant handgrip for the male sample participants can be written as the following: Handgrip variable = 6.705 + (0.047 × hand volume variable) + (0.201 × weight variable) + (0.340 × forearm circumference variable).

Conclusions

It can be suggested: 1) The independent variables (hand volume, weight, and forearm circumference) have a significant impact on the strength of dominant handgrip among the male sample; 2) The highest contribution to the dominant handgrip's strength for the male sample was for the variable of hand volume, then the weight variable, then the variable of forearm circumference; 3) Extracting the predictive equation for the strength of the dominant handgrip for males as follows: Handgrip variable = 6.705 + (0.047 × hand size variable) + (0.201×weight variable) + (0.340 ×forearm circumference variable).

Recommendations

It can be recommendated: 1) Repeat this study using the grip strength of the non dominant hand; 2) Applied these variables of handgrip for dominant and non dominant on the female students; 3) Repeat this study using professions athletics in sports that require a high level of grip strength, such as wrestling, gymnastics and throwing activities in track and field.

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PREDIKCIJA SNAGE STISKA ŠAKE TEMELJENA NA NEKIM MORFOLOŠKIM MJERAMA, VOLUMENU RUKE I PODRUČJU OTISKA ŠAKE

Sažetak

Ova studija usmjerena na izgradnju prediktivne jednadžbe za dominantnu ruku i to snage stiska šake temeljeno na nekim antropometrijskim mjerenjima, volumenu ruke i području otisku prostora za studente tjelesnog odgoja. Uzorak ove opisne studije je sastavljen od 281 muškaraca. Izmjerene su slijedeće varijable: visina, težina, indeks tjelesne mase, volumen ruku, područje makrootiska šake, zglob i podlaktica i nadlaktica opseg i snaga stiska za dominantne ruke učenika. Istraživanje je pokazalo da većina varijabli koje doprinose učinkovito i statistički značajno snazi rukohvata su: volumen ruke, težina i opseg podlaktice. Na kraju je prikazana prediktivna jednadžba za snagu stiska.

Ključne riječi*: prediktivna jednadžba, stisak šake, anthropometrija, volume ruke, područje otiska ruke*

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