International Journal of Physical Education, Sports and Health 2022; 9(4): 299-303

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (RJIF): 5.38
IJPESH 2022; 9(4): 299-303

www.kheljournal.com
Received: 01-07-2022
Accepted: 04-08-2022

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Predicting lower body explosive strength using hand grip dynamometer strength test

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DOI: https://doi.org/10.22271/kheljournal.2022.v9.i4e.2610

Abstract
Problem statement: Numerous fitness tests are usually administered to determine either muscular strength or cardiovascular endurance. Even though an ample number of tests exist to measure upper body muscular endurance and lower body maximal muscular strength, a single test that assesses both could be beneficial in some circumstances.
Purpose: The purpose of this study was to determine if a hand-grip dynamometer strength test is a valid predictor of lower body explosive strength.
Methods: Participants included 164 college students including both genders included boys = 83, (age 20.72±2.82 yrs., height 170.28±5.48 cm, weight 62.01±9.55 kg) and girls = 81, (age 20.64±2.74 yrs, height 159.30±5.68 cm, weight 55.71±8.14 kg). Subjects performed the standing broad jump (SBJ) for lower body explosive strength. Subjects performed 3 trials of the dominant hand grip strength (*d*HGS) test, after which the maximum value was recorded. Pearson bivariate correlation analyses were used to determine relationships between measures. Simple linear regression with enter method was performed to predict variation in lower body explosive strength through the hand grip dynamometer strength test.
Results: Significant correlations were found between *d*HGS and SBJ ($r = .802$, $p<0.05$), A simple linear regression was calculated to predict BMI based on HGS. The regression was found statistically significant ($R^2 = .642$, $F(1, 162) = 291.036$, $P<0.05$). Following reference equation [SBJ = (0.974) + (0.015) × *d*HGS] was developed to predict lower body explosive strength.
Conclusions: The hand grip dynamometer strength test was a significant predictor of lower body explosive strength. The reference equation calculated implicates its usefulness as a method to predict lower body explosive strength simply through the hand grip dynamometer strength test.

Keywords: Grip strength, lower body explosive strength, reference equation

Introduction

Hand grip strength can be quantified by measuring the amount of static force that the hand can squeeze around a dynamometer. The force has most commonly been measured in kilograms and pounds, but also in milliliters of mercury and Newtons (Massy-Westropp *et al*., 2011) [16]. Published normative data for hand grip strength are available from various countries and in most cases, data are divided into age and gender sub-groups (Angst *et al*., 2010; Bassey & Harries, 1993; Bohannon *et al*., 2006a; Massy-Westropp *et al*., 2011; Mathiowetz *et al*., 1985) [2, 3, 5, 16, 17]. Analysis of grip strength by gender shows higher grip strength by males at all ages, and analysis by age group demonstrates a peak of grip strength in the fourth decade and then a gradual decline in grip strength for both genders.

Grip strength is related to and predictive of other health conditions (Bohannon, 2008) [8]. Such prediction is important for identifying individuals who are at risk of untoward future events and for determining appropriate targets for risk-reducing efforts. Although lower body explosive muscle strength is an essential component of physical fitness examination (Nara *et al*., 2022; NARA *et al*., 2022) [26, 27], as well as lower body explosive strength is a determinant factor in power sports. Besides, that normal hand grip strength is positively related to bone mineral density (di Monaco *et al*., 2000; Kumar, 2014, 2017, 2018) [7, 12, 13, 14] with some researchers suggesting that grip strength is a screening tool for women at risk of osteoporosis (Karkkainen *et al*., 2009) [9]. Longitudinal studies suggest that poor grip strength is predictive of increased mortality from cardiovascular disease and cancer in men, even when factors of muscle mass and body mass index are adjusted (Gale *et al*., 2007) [8]. The available studies are working on hand grip strength as a tool for early detection of old-age mortality. While various studies reported the usefulness of hand grip strength to identify muscle mobility in patients after surgery. Sufficient literature on the global perspective is available on reference or normative values of hand grip strength (Amaral *et al*., 2019; Bohannon *et al*., 2006b; Kim *et al*., 2018; Tsang, 2005) [1, 6, 10, 31]. The disparity exists in the literature over the relationship between hand grip strength and overall muscular strength in the context of the young population of both genders. Is hand grip strength could be a sole predictor of overall muscular health? is a gap in the literature, which need to be identified. Few studies have reported reference equations to predict body composition and muscular strength of upper and lower extremities by hand grip strength (Y.-C. Wang *et al*., 2018) [13]. These equations can be used in schools and colleges to predict the overall muscular strength by hand grip strength.

The present study aimed to establish the relationship between hand grip strength and lower body explosive strength. Moreover, to develop a reference equation of lower body explosive strength by hand grip strength dynamometer test.

Material & Methods

Study design

An observational cross-sectional study was performed from January 2022 to May 2022. The work was performed in two colleges affiliated with Chaudhary Ranbir Singh University, Jind, i.e., Govt. College Jind, Priyadarshini Indira Gandhi College, for women, (PIGC) Jind as well as the university campus were randomly selected by the researcher. Before the study commences, approval for the research was obtained from the department of physical education, Chaudhary Ranbir Singh University, Jind, Haryana, India, and informed consent was obtained from each participant.

Participants

The study included 164 college students of both genders (Boys = 83, Girls = 81). The age of the subjects ranged from 18 to 24 years with mean±SD of boys = 20.72±2.82 years, and girls = 20.64±2.74 as well. Students were selected from the colleges using the following criteria: physically normal, able to perform normal activities of daily living. Students were excluded if they had undergone orthopedic or neuromuscular surgery in their upper limbs, if they had a musculoskeletal problem that affects their upper extremities, or if they had visual, auditory, or vestibular defects.

Table 1: Descriptive statistics following mean and standard deviation of the selected variables with measuring units and abbreviation used

Variables	Measuring Units	Boys (N = 83)				Girls (N = 81)			
		M	SD	Min	Max	M	SD	Min	Max
Age	Years	20.72	2.82	18	24	20.64	2.74	17	24
Height	Centimeters	170.28	5.48	160	183	159.30	5.68	149	170
Weight	Kilograms	62.01	9.55	45	91	55.71	8.14	41.75	82.05
Body mass index (BMI)	kg/m^2	21.33	2.68	16.42	29.49	21.87	2.23	17.18	28.39
Standing Broad Jump (SBJ)	Meter	1.72	.21	1.30	2.10	1.21	.13	.95	1.55
Hand Grip Strength (*d*HGS)	Kg	45.75	12.60	18	66	18.95	3.78	12	30

M = mean, SD = standard deviation, Min = minimum values, Max = maximum values, *d*HGS = dominant hand grip strength

Measurement of hand grip strength

Measurement of hand grip strength was measured using a Baseline Camry 200 Lbs / 90 Kgs Digital Hand Dynamometer in kilogram with participants seated, their elbow by their side and flexed to right angles, and in a neutral wrist position. The dynamometer handles position II and provision of support underneath the dynamometer. This position, followed by the calculation of the mean of three trials of grip strength for the dominant hand, has been well-documented as reliable (Shechtman & Sindhu, 2016) [30]. Five assessors were trained in the use of the dynamometer according to this protocol and practiced the testing procedure before assessments.

Participant's BMI was calculated following the measurement of each participant's height and weight using the following formula:

$$\text{Body mass index (BMI)} = \frac{\text{Weight in Kg}}{\text{Height in meter}^2}$$

Measurement of lower body explosive strength

The explosive leg power was assessed through a standing broad jump (SBJ) test. The students stand behind a line marked on the ground with feet slightly apart. A two-foot take-off and landing are used, with the swinging of the arms and bending of the knees to provide forward drive. The subject attempts to jump as far as possible, landing on both feet without falling backward. The measurement is taken from the take-off line to the nearest point of contact on the landing

Table 2: Coefficients of regression with model summary of SBJ as dependent variable

Model		Un-standardized Coefficients	Standard Coefficients	t	Sig
	B	Std. Error	Beta		
Intercept	.974	.032		30.197	.000
Slope	.015	.001	.802	17.060	.000

Modal Summary: [R = .802, R^2 = .642, F (1, 162) = 291.036, $p<0.05$).]

Statistical Analysis

All statistical analyses were performed using SPSS statistics for windows version 26.0 (IMB Corporation, Armonk, NY). High-resolution graphs were reproduced using Origin Pro version 2022 (Origin Lab Corporation, Northampton, Massachusetts, USA). Descriptive statistics of selected variables were tabulated for relevant strata (See Table 1). Before, initiating the final analysis, the obtained data were checked for assumptions of normality. Kolmogorov-Smirnov tests of normality were performed to ensure data distribution. No significant fluctuation among data was observed. Before generating the regression equation, Pearson correlation coefficients were used to explore the relationship between grip strength as an independent variable and SBJ as dependent variable. Mukaka guidelines (Mukaka, 2012) [19] was used to interpret correlation coefficients in medical research: greater than 0.9 (very high), 0.7 to 0.9 (high), 0.5 to 0.7 (moderate), 0.3 to 0.5 (low) and less than 0.3 (negligible). Simple linear regression with enter method was used to generate an explanatory equation for grip strength. Model fit was inspected using the overall F test for the regression model, individual *t*-test for each regression coefficient, and adjusted R^2. Bland-Altman plots were used to identify the systematic difference between observed and predicted values of an equation or possible outliers. The mean difference is the estimated bias, and the SD of the differences measures the random fluctuations around this mean. It is common to compute 95% limits of agreement for each comparison (average difference±1.96 standard deviations of the difference), which tells us how far apart measurements by two methods were more likely to be for most individuals. To reduce the risk of type 1 error, a significant level of $p<0.05$ was adopted as an indicator of statistical significance.

Results

Table no 1 summarizes the descriptive statistics in terms of mean, SD, minimum and maximum values followed by measuring units. As shown in Table no 2, a high degree of positive correlation (r = .802) was found between *d*HGS and SBJ. The model was statistically significant with calculated F (1, 162) = 291.036, $p<0.05$). While, calculated 't' test was also significant (t = 30.197, $p<0.05$), which accepts the statistical hypothesis of linearity between the response variable and the predictor variable.

Figure 1 scatter plot showing the correlation (and 95%confidence interval of the regression line) between the *d*HGS and SBJ. The prediction equation was also mentioned in the scatter plot under the reference line. Figure 2 Bland-Altman plot showing mean difference and 95% confidence interval of selected variables in the observed and predicted values calculated by reference equation.

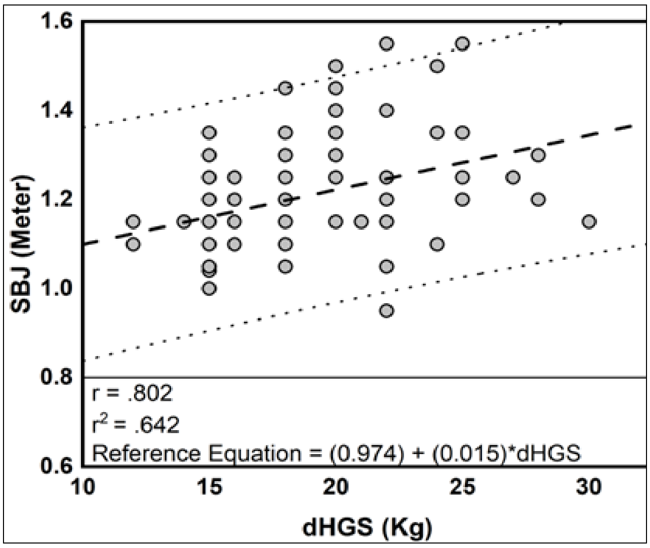

Fig 1: Scatter plot showing the correlation (and 95% confidence interval of the regression line) between SBJ and *d*HGS

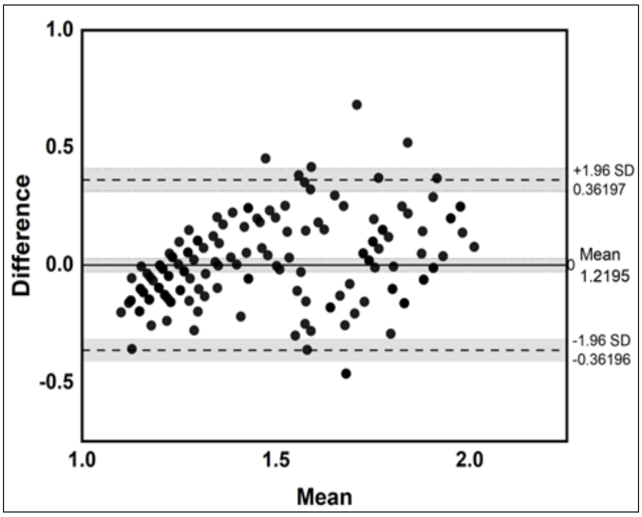

Fig 2: Bland-Altman showing mean difference with 95% limits of agreement between observed and predicted values of SBJ

Discussion

Handgrip strength has been suggested as a biomarker of muscular strength. It is a crucial and easily available indicator of current health status and predictor of future outcomes (Nara, 2017b, 2018; Wiśniowska-Szurlej *et al*., 2019) [23, 25, 34]. This study presents a normative reference equation of lower body explosive strength by *d*HGS. The particular equations are based on data obtained from Indian college youth ages ranging from 18 to 25 years. The normative reference equation provided in this study will be helpful for the assessment of the lower body explosive strength of college students. Recently no reference equation is presented in the literature which predicts the leg explosive strength of college students. The provided reference equations will be helpful to predict leg explosive strength using the HGS values of an individual.

In this study, a significant relationship was reported between the parameters of muscular strength and HGS. Besides the particular study, sufficient literature evident the relationship between HGS and upper and lower body strength (Mizukami *et al*., 2022; Nara, 2017a, 2017c; Rhodes *et al*., 2022; Zhang *et al*., 2022) [18, 22, 24, 29, 36]. These different parameters are a good indicator of muscular strength. The tests of the following parameters are difficult to administrate and need sufficient time to set up the test procedure. Therefore, the normative reference equation provided in this study may be beneficial for diverse medical and ergonomic research, enabling clinicians, coaches, trainers, and researchers to compare the grip-strength values in individuals with or without impairments to the reference values established based on the general, relatively healthy population. If someone is interested to attain the leg explosive power of an individual through provided equations. He/she just needs the HGS value of the particular individual. For example, the HGS values of subject is 40 kg, then their SBJ will be (0.974) + (0.015) × 40 = 1.574 meter respectively.

The all-around development strategy of quality education makes college students not only pursue the improvement of academic achievement but also carry out physical exercise. Having a strong body helps students have certain physical strength to study in other courses (Nara, 2013, 2015, 2017c; J. Wang *et al*., 2022) [21, 20, 24, 32]. Assessment of physical fitness in educational settings is a costly and complex task due to the strength of the subjects. In this situation, HGS is a valid tool to measure physical fitness (Parveen, n.d.).

In the context of HGS, it is also important to acknowledge global standards of HGS for both genders. Previous studies have developed normative data for a specific population. Kyung-Sun & Lee Jaejin Hwang (Kumar *et al*., 2022; Lee & Hwang, 2019) [14, 15] reported a comparative evaluation of Asian, European, and United States populations. The studies conducted in these continents with different age groups are reported by the researcher. The average HGS values reported in these studies are used for comparative evaluation with the outcomes of the present study. The mean grip strength for Americans was higher at 49.23 kg for males; 27.67 kg for females than Europeans 47.22 kg for males, and 28.84 kg for females respectively, while Asians have the lowest mean grip strength with 40.56 kg and 24.85 kg for females. In the present study, the mean HGS of boys was 45.75 kg showing near to American and European populations for the 18 to 25 years of age group. The mean HGS of girls was 18.95 kg, which reports a significant reduction in the comparison of global standards. Several factors may be responsible for these outcomes such as nutrition intake, low birth weight, physical inactivity, participation in sports, and other social issues, which are further areas of interest to be investigated.

Conclusions

The hand grip dynamometer test was a predictor of muscular strength. The lower body explosive strength can be predicted through provided reference equation. The reference equations calculated implicate its usefulness as a method to predict muscular strength simply. The results apply to anyone interested in testing muscular strength in group settings; or with special populations. The predictive value of the HGS could serve as a useful tool to predict muscular strength and endurance that would normally require a more complex assessment. HGS testing requires only a single piece of equipment and minimal effort from subjects who may be unwilling or unable to perform the other more strenuous tests.

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