Efficacy of Handgrip Strength in Predicting Total Body Strength Among High Performance Athletes

Lucy Jawan, Rahmat Adnan, Norasrudin Sulaiman and Shariman Ismadi Ismail

Abstract The purpose of this study was to determine the efficacy of handgrip strength in predicting total body strength among high-performance male athletes. A total of 100 male athletes (mean ± SD), with a mean age of 20.92 years old (±2.53) and BMI 24.77 kg/m^2 (±4.70), were willing to participate in this study. All subjects were considered as high-performance athletes as they represented their university, state, or country in sports and were reported as being healthy and fit through the interview sessions held before selecting them into the program. Subjects were required to perform indirect 1RM test (lat pull-down, incline bench press, leg press, and leg extension), handgrip strength test, and the vertical jump test. The handgrip strength test was evaluated using the digital handgrip dynamometer (Takei A5401) to test the handgrip strength test. Meanwhile, the Vertec vertical jump equipment was used to determine the leg power. The data were analyzed using the Statistical Package for the Social Science (SPSS) version 19.0 with the significance level set at $p \leq 0.05$. This study found that the handgrip strength test showed no significant correlation between all the 1RM tests, including the bench press (0.057), lat pull-down (0.304), the leg press (0.113), leg extension (0.015), and strength test. Likewise, the leg power test also showed no significant correlation (0.119) with the handgrip strength test. Hence, this study showed that the handgrip was not a significant measure of total body strength of high-performance athletes.

Keywords Component · 1RM test · Total body strength · Handgrip strength · High-performance athletes

L. Jawan
Strength Training and Conditioning Laboratory, Universiti Teknologi MARA, Shah Alam, Malaysia

R. Adnan (✉) · N. Sulaiman · S. I. Ismail
Faculty of Sports Science and Recreation, Universiti Teknologi MARA, Shah Alam, Malaysia
e-mail: rahmatadnan@salam.uitm.edu.my

R. Adnan et al. (eds.), *Proceedings of the International Colloquium on Sports Science, Exercise, Engineering and Technology 2014 (ICoSSEET 2014)*,
DOI: 10.1007/978-981-287-107-7_4,

1 Introduction

In general, high-performance athletes have high total body strength compared to other athletes and the general population. Strength is an essential function of the human body, which can manifest itself in various ways, depending on individual conditions and objectives used to perform different actions or exercises. The term "strength" can be employed to identify the force or torque developed by a muscle during a particular joint movement [1]. Handgrip strength is an important measure of general health and is regarded as one of the most reliable clinical methods for estimating strength [2, 3] and determines the handedness of an individual, an important field of population variation study. It is often used as an indicator of overall physical strength and is affected by a number of factors including age, gender, and body size [4, Elissa, Title of paper if known, unpublished].

Besides handgrip strength test, the one repetition maximum (1RM) testing is another way to predict specific muscular strength in athletes. The 1RM test is a method widely used for the determination of the intensity of strength training [5]. Besides, the 1RM test is considered the gold standard for assessing muscle strength in non-laboratory situations [6]. It is defined as the maximal weight that can be lifted once with proper lifting technique. It requires comparatively easy and inexpensive non-laboratory equipment. Due to the wide use of 1RM testing, the 1RM measurement is very important. Mostly, exercises such as the bench press and squat have been shown to be reliable measurements for 1RM testing [6]. The 1RM test goal is to mobilize the greatest possible resistance via a specified range of movements (ROM), without additional feedback on the rate of force development (RFD), or time consumed producing the movement [1]. Handgrip strength measurements are reliable, safe, easy, and fast to perform [7]. Besides, handgrip strength is suitable for prediction of total body strength in healthy young adolescents [8]. Most of the previous studies on handgrip strength were carried out on the general population; however, there was only limited studies carried out among high-performance athletes particularly in Malaysia.

Therefore, the purpose of this study was to estimate the efficacy of handgrip strength in predicting total body strength among high-performance athletes.

2 Methodology

2.1 Sample

One hundred ($N = 100$) male athletes at high-performance level from two categories of sports (individual sports and team sports) were selected to perform the indirect 1RM strength test, handgrip strength test, and the vertical jump test.

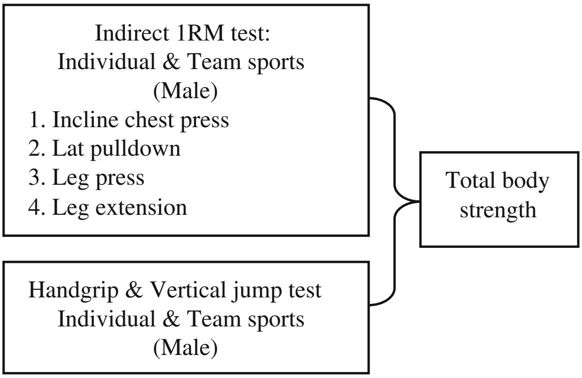


Fig. 1 Research framework

2.2 Research Design

This study used correlations in order to find the relationship between total body strength with handgrip strength among high-performance athletes.

Besides, this study was also designed to find the relationship and differences in the dominant versus non-dominant hand for the handgrip strength between the two types of sports (individual and team sports) (Fig. 1).

2.3 Test Instrument

The Faculty of Sport Science and Recreation Gymnasium UiTM was used as the venue for the data collection.

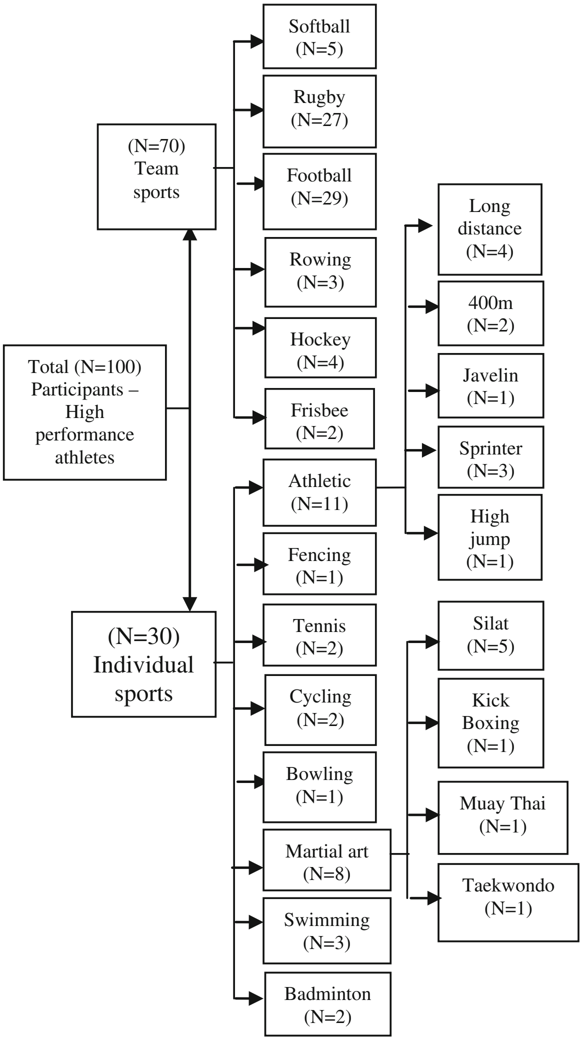
2.3.1 Handgrip and Vertical Jump Test

Takei A5401 (Japan) digital handgrip dynamometer was used to measure the handgrip strength among the high-performance athletes. The Vertec device was used for measuring vertical jump height in order to obtain muscular power of the participants.

2.3.2 Indirect 1RM Test

The Olympic bar was used on an incline bench press (45° angle) test to identify the specific frontal upper body strength. The Cybex dual axis pull-down machines were used to measure the back posterior muscles that comprises of Latissimus dorsi, rhomboid, and posterior deltoid. Leg extension machine was used in the leg extension test to measure quadriceps muscles alone, which were the most dominant muscles in the leg.

Fig. 2 Sampling procedure



2.4 Data Collection

This study began with the indirect 1RM strength test (incline bench press, lat pull-down, leg extension, and leg press).

After 72 h, all of the participants went through the second phase of the test, which began with the handgrip strength test and followed by the vertical jump test [8]. A rest period was given for muscle recovery after participants underwent the indirect 1RM tests in order to get the best result for total body strength (Fig. 2).

2.5 Procedure

Participants were required to sign the informed consent form. Then, the basic demographic (age, gender) and anthropometric (height, weight, body mass index) data were obtained.

Next, the participants were allowed to perform individual warm-up sessions by running on a treadmill for 5 min at moderate intensity and for a brief familiarization with the equipment. The indirect 1RM test (lat pull-down, bench press, leg extension, and leg press) and vertical jump test were conducted by experienced sports science practical students (Fig. 3).

2.5.1 1RM Strength Testing

Participants warmed up prior to testing by running for 5 min on a treadmill. After a 1-min rest period, participants were familiarized with each of the resistance machines by performing 8–10 repetitions of a light load (~50 % of predicted 1RM). After 1 min of rest, participants performed a load (~80 % of estimated 1RM) through the full range of motion. After each successful performance, the weight was increased until a failed attempt occurred. One-minute rests were given between each attempt, and the 1RM was attained within 5 attempts and 5-min rest separated each test [6]. In order to facilitate the recovery and reduce the effect of fatigue, exercises were alternated between the upper and lower body [6]. The orders of the test were as follow: incline chess press, leg press, dual axis pull-down, and leg extension. After determining the 1RM value and allowing 72 h of rest, the maximum repetitions to failure for eight different sub-maximal percentages was assessed (30, 40, 50, 60, 70, 80, 90, and 95 % of 1RM) [1].

2.5.2 Handgrip Strength Testing

To perform this test, the participants have to squeeze a *Takei* dynamometer as strongly as possible with a hand, which is held in a rotationally neutral position. The width of the grip is individually adjusted; once the handgrip dynamometer was adjusted to the size of the player's hands, each subject performed three attempts trying to reach the peak force [9]. The test is executed in the standing position, with the arm extended downward along the body for 90° and 180° both for the left and right hand [10]. Thirty-seconds to one-minute time intervals were maintained between each of the handgrip strength testing [11]. The results were recorded in kilogram (kg).

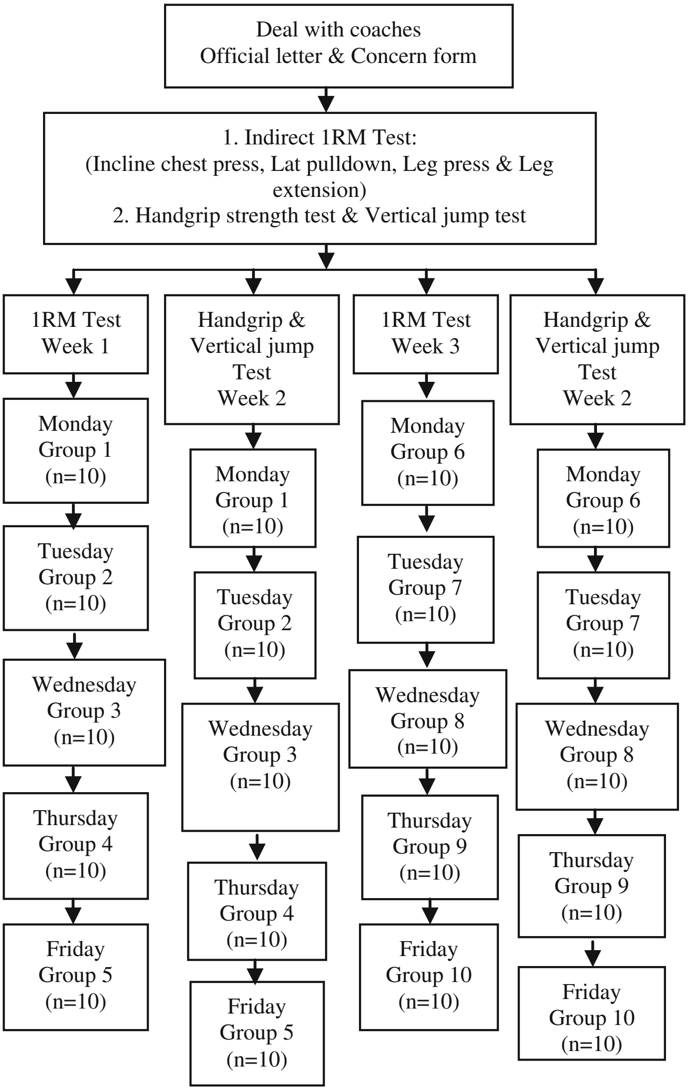


Fig. 3 Procedure chart

2.5.3 Vertical Jump Testing

The athletes were required to perform adequate warm-up and stretching prior to testing. The athletes are required to stand below the Vertec device, without moving the feet, bend the knees, and jump as high as possible to displace the markers. The athletes were given three trials. The best of the three trials were recorded to be analyzed.

Table 1 Demographic profile of subjects

Variable	Male ($N = 100$)		
	Mean ± SD	Min	Max
Age in years	20.92 ± 2.53	18	30
BMI	24.77 ± 4.70	18	43

2.6 Data Analysis

Data were analyzed using the Statistical Package for Social Science (SPSS 19.0) software. Descriptive statistics were used to analyze the data to seek the means and standard deviations of participant's age and BMI besides, finding the range of the difference between the dominant and non-dominant hand.

It was observed that the data for the individual and team sports met the assumptions for parametric statistics, in which there were two categories (individual and team sports), with independent observations and a normal population ($N > 30$) based on the central limit theorem (CLT). Thus, the independent-sample t test was used to compare the score of handgrip strength tests between individual and team sports. Hence, the median and standard deviations were used to determine which result showed the highest.

The Pearson's correlation was used to determine the relationships between the handgrip strength with 1RM strength tests and the vertical jump test. The values were between +1 and −1 inclusive.

3 Data Analysis and Results

The mean age in years for participants was 20.92 (±2.53), while the youngest was 18 years old and the oldest was 30 years old (Table 1). The mean value for BMI was 24.77 (±4.70), while the lowest value for BMI was 18 and the highest was 43.

There were weak positive correlations between both dominant extension and dominant 90° elbow flexion with indirect 1RM strength (lat pull-down and leg press) and the vertical jump (Table 2). However, there was a weak negative correlation between handgrip strength with indirect 1RM test for leg extension. Therefore, athletes who had high scores for indirect 1RM strength does not really tend to have high scores for the handgrip strength test, except for leg extension.

The range strength for dominant 90° elbow flexion was 41.8 kg and for elbow extension was 40.5. Hence, there is no significant different between elbow position. The differences of range strength between the dominant and non-dominant side for both 90° elbow flexion and elbow extension handgrip strength test among high-performance athletes were 8.2 and 3.1 kg, respectively, (Table 3). Range reflects the distance from the minimum to the maximum score.

Table 2 Pearson's correlations between the arm extension handgrip strength test, the indirect repetition maximum test, and the lower body power test

Indirect 1RM test	Dominant extension	Dominant 90° elbow flexion
Incline bench press	0.057	0.109
Lat pull-down	0.304**	0.345**
Leg press	0.113	0.065
Leg extension	−0.015	0.018
Vertical jump	0.119	0.154

**Correlation is significant near to ±1

Table 3 Descriptive statistics of differences range strength between the dominant and non-dominant side for the 90° elbow flexion and elbow extension handgrip strength test

Variables		*N*	Range (kg)	Min (kg)	Max (kg)
90° elbow flexion	Dominant	100	41.8	24.6	66.4
	Non-dominant	100	33.6	25.1	58.7
	Different	100	8.2	0.5	7.7
Extension	Dominant	100	40.5	30.1	70.6
	Non-dominant	100	37.4	25.5	62.9
	Different	100	3.1	4.6	7.7

Table 4 Independent-sample t test for 90° elbow flexion handgrip test and elbow extension handgrip between individual sports and team sports

Variables		*n*	Mean ± SD	Sig (2-tailed)
Extension dominant	Individual sports	30	48.26 ± 8.08	0.354
	Team sports	70	46.59 ± 8.43	
Extension non-dominant	Individual sports	30	43.60 ± 7.35	0.673
	Team sports	70	38.74 ± 6.75	
90° elbow flexion dominant	Individual sports	30	44.57 ± 8.05	0.096
	Team sports	70	41.67 ± 7.70	
90° elbow flexion non-dominant	Individual sports	30	40.50 ± 7.20	0.237
	Team sports	70	38.74 ± 6.75	

The mean of handgrip strength test of dominant elbow extension showed highest results in both individual and team sports (Table 4). For individual sports, the mean for dominant elbow extension was 48.26 (±8.08) and for the dominant 90° elbow flexion, it was 44.57 (±8.05). Meanwhile, the mean in team sports for the dominant elbow extension was 46.59 (±8.43) and for the 90° elbow flexion, it was 41.67 (±7.70). Hence, this showed that individual sports gave higher results on handgrip strength compared to team sports.

4 Discussion

Based on the results of this study, there was no significant relationship in handgrip and indirect 1RM strength tests among high-performance athletes. All indirect strength tests as selected were represent major muscles group. From all strength tests, there was only lat pull-down exercise that shown very low relationship between two elbow positions. However, this relationship was very weak to accept its finding and this answering all high-performance athletes may have their specific muscle strength based on their selected sports. However, handgrip strength test is suitable for prediction of total body strength in healthy young adolescents [8]. Besides, the handgrip strength test is one of the most reliable clinical methods for estimating strength [12].

This study found there was no significant different between elbow position. This finding was supported by previous study done by Carrasco et al. [9] found that there was small different grip strength between dominant and non-dominant hand. However, this study contra with Rahmat et al. [13] finding as elbow extension position shown with superior strength compare to flexion position.

There were significant differences in strength between the dominant and non-dominant hand among high-performance athletes. The maximum strength of hand was higher in the dominant versus the non-dominant hand, both for left-handed and for right-handed high-performance athletes. Similar results were reported in a previous study on table tennis players [9].

The findings of the present study also found that there was no significant relationship in the handgrip strength between individual and team sports. Individual sport is believed to give higher results of handgrip strength, which is considered as total body strength, compared to team sports. This is because different types of sports have different levels of strength and power demands [14]. The velocities that elicited maximal power in the lower extremities were lower than in the upper extremities [14].

However, this study group was limited to healthy male high-performance athletes (age range 18–30 years). One handicap was the lack of a female study group. However, according to Ertem et al. [15], the increase in grip strength was similar in both genders and appeared to be independent of sex hormones.

5 Conclusion

This study found handgrip strength test is not sensitive to predict muscle strength among high-performance athlete. Thus, handgrip strength is not recommended tool in measuring muscular strength in high-performance athlete.

Acknowledgments The researcher would like to express their utmost gratitude to RMI—UiTM RAGS for funding this study. We would also like to thank the Faculty of Sports Science and Recreation Shah Alam campus for giving this opportunity to complete this research project within the time frame.

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