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Original Article

Physiotherapy Section

Handgrip Strength as a Predictor of Muscular Strength and Endurance: A Cross-sectional Study

SHLESHA MAULIK VAIDYA[1], DARSHANA M NARIYA[2]

ABSTRACT

Introduction: Reliable muscle strength measurement of individual muscle groups is time-consuming and so it would be convenient to have a single, quick and simple tool as an indicator of the general muscle strength. Handgrip strength might be an adequate measurement for generalised muscle strength. It has a low cost and may be used in a time-efficient manner in clinical setting.

Aim: To determine if a handgrip dynamometer test is a valid predictor of both muscular strength and endurance and to provide a gender specific reference charts for handgrip and establish correlation between BMI and handgrip.

Materials and Methods: It was a cross-sectional study, conducted from October 2017 to March 2018. Participants included 30 college students, 10 males and 20 females of 18 to 25 year age group. BMI of all subjects were measured. Handgrip strength was measured by adjustable handgrip dynamometer. Horizontal Jump Test (HJT) and Vertical Jump Test (VJT) were used to measure lower limb muscle strength. To evaluate the strength of the trunk, one minute curl-ups test was used. Aerobic power was measured by VO_2 max Cooper's test.

Results: Significant correlation found between handgrip strength and HJT ($r=0.8226$, $r^2=0.6767$, $p<0.05$), handgrip strength and VJT ($r=0.6917$, $r^2=0.4764$, $p<0.05$), handgrip strength and VO_2 max ($r=0.7204$, $r^2=0.519$, $p<0.05$), handgrip strength and BMI ($r=-0.1341$, $r^2=0.018$, $p<0.05$), handgrip strength and one minute curls-up test ($r=0.4368$, $r^2=0.1908$, $p<0.05$). Although there was weak correlation of handgrip strength with BMI and one minute curls-up test.

Conclusion: Handgrip strength can be an effective tool for predicting muscular strength and endurance.

Keywords: Dynamometer, Fitness, Health

INTRODUCTION

Physical fitness has been related with many health components [1] and physical performance [2]. There are evidences demonstrating that physical fitness could predict musculoskeletal, cardiopulmonary and metabolic disorders [3,4]. It also has important effects on cognitive function, memory performance and academic achievement [5,6]. Muscle strength is one of the important aspects of physical fitness and health. Reduction in muscle strength may cause limitation in function [7,8]. Hence, muscle strength is an important indicator of health [9]. In the last years, muscle strength has been considered as a significant component of health regardless of age [10,11] and clinical condition [12].

Several fitness tests have been designed to determine either muscular strength or endurance. Various tests have also been designed to measure upper body muscular endurance and lower body maximal muscular strength. A single test that assesses muscular endurance, strength and is a reliable indicator of general strength can be easy to administer and time-saving [13]. There exists a relationship between grip strength and various functional, clinical, psychological orpsychosocial parameters [11,14]. Maximal Grip Strength (MGS) is measured to predict various outcomes like growth, aging, injury and training. Its measurement is performed using dynamometers, which estimate the muscle strength primarily generated by the flexor muscles of the hand and the forearm [15]. Hence, handgrip strength might be an adequate measurement for generalised muscle strength [16-18]. It has a low cost and may be used in a time-efficient manner in clinical setting [19].

The primary purpose of this study was to determine whether grip strength is a predictor for total muscle strength and endurance. The secondary purpose of this study was to provide gender and weight related reference charts for grip strength. In this study, the authors correlated handgrip strength with BMI, HJT, VJT, one minute curls-up and VO_2 max respectively in order to study the correlation between handgrip strength and other variables in terms of muscular strength and endurance.

MATERIALS AND METHODS

It was a cross-sectional study, conducted from October 2017 to March 2018. Subjects were recruited from SPB Physiotherapy College, Surat. Written informed consent was obtained from the volunteers. The study was approved by the Research Ethics Committee of the Institution (EC/SPB/31).

Sample Size Calculation: It was based on level of significance set at 0.05, power set at 80% and the expected correlation coefficient set at 0.5 [20]. The sample size required according to this calculation was 28. Thirty participants, that agreed to participate in the study, were informed of the study objectives, procedures and risks.

Inclusion Criteria: Students willing to participate in age group of 18 to 25 years of both the sex were included.

Exclusion Criteria: Volunteers under treatment for acute or chronic cardiovascular, pulmonary, metabolic or vascular disease. Those using any drugs known to affect the cardiovascular or respiratory system. Those with central or peripheral nervous system disorders, those undergone surgery in the last three months. Those for whom bed rest had been prescribed in the last three months and those with any orthopaedic disorder that would limit their physical performance wew excluded.

Procedure

a. **Anthropometrics measurements:**
Body height and weight were measured with a stadiometer and a digital scale, respectively, without shoes or heavy clothing to the nearest centimeter and 100g, respectively. Body Mass

Index (BMI) was calculated as body weight in kilograms divided by the square of body height in meters [21].

b. **Handgrip strength:**

Maximal isometric handgrip strength was measured with an adjustable handgrip dynamometer. The handgrip was measured in Newtons (N). The test was performed twice for each hand, alternating between right and left hands to avoid muscle fatigue. Participants were instructed to squeeze the handgrip with possible maximum effort, with an outstretched arm. The sum of the best result for the right and left hand was used in the analysis [22].

c. **Lower limb strength:**

To estimate muscle strength of the lower limbs, Authors applied horizontal and vertical jump test. In the Horizontal Jump (standing long jump) Test, subjects were asked to stand behind a line on the floor, with their feet parallel to each other and spread to shoulder width, and then jump forward as far as possible. They were asked to crouch down and using the arms and legs, jump horizontally as far as possible landing with both feet. A distance from the starting point to the nearest impression made by the subject was measured. Subject was asked to repeat the test 3 times. The longest recorded distance was used to assess the subject's leg strength and thereafter further in analysis [22].

In the VJT subjects were asked to stand facing a wall keeping both feet on ground, extend their arms in front of them, with the end of his/her finger-tips chalked and marks the wall with tips of fingers (V1). Then, they were asked to jump as high as possible while keeping their arms parallel to the floor (i.e., not using their arms to impel themselves upward) and mark the wall with chalked finger-tips (V2). The vertical jump height will be defined as the difference between V1 and V2. The best of three attempts were recorded and included in the analysis [22].

d. **One minute curl-ups:**

To evaluate the strength of the trunk, Authors employed the curl-up test. Subjects were asked to lie on their backs, with their hips and knees flexed and their arms crossed over their chests, and do as many curl-ups as possible during a period of 60 seconds. Only complete curl-ups (those in which the forearms touched the thighs) were counted [22].

e. **Aerobic power:**

To evaluate the aerobic capacity in terms of VO_2 max, Cooper's test was employed. For that a 400 meter track was marked out on the ground to conduct Cooper's test. On the day of the experiment, initially pre-vitals of the subject were measured and recorded after which they were asked to stand at the starting point. The experimental subjects were instructed to run/walk as many lap of 400 meter track as possible for the period of 12 minutes. After exact 12 minutes the subjects were asked to stop running/walking, instructed to sit after which postvitals were measured immediately and again after 5 minutes. Then total distance in meters covered after 12 minutes by the experimental subjects were recorded [23].

VO_2 max was predicted by using the following formula:

VO_2 max (mL/kg/min)=(22.351×distance covered in kilometers)-11.288 [23].

STATISTICAL ANALYSIS

SPSS 14 was used Pearson correlation coefficient [24] was used to find out correlation between: Hand grip strength and BMI values, Hand grip strength and calculated power of subjects in HJT, Hand grip strength and calculated power of subjects in VJT, Hand grip strength and total number of curl-ups in one minute curls-up test, Hand grip strength and VO_2 max calculated in Cooper's Test. A p-value less than 0.05 was considered statistically significant.

RESULTS

The mean age of the males was 20.8±1.317 years and 20.5±0.688 years for females. The mean value of BMI for male was 19.2±2.693 kg/m^2 and 21.16±3.93 kg/m^2 for females. The mean value of hand grip strength was 67.4±2.701 kg for males and 45.25±3.508 kg for females [Table/Fig-1]. [Table/Fig-2] shows reference values for handgrip strength in relation to BMI.

The values of HJT were in the range of 60.3-200 cm and mean was 134.4±67.3 cm. There was a very strong positive correlation between handgrip strength and HJT. r=0.8226 and r^2=0.6767 ($p<0.05$).

	Male		Female		p-value
	Mean	Standard deviation	Mean	Standard deviation	
Age (years)	20.8	1.317	20.5	0.688	0.224
Weight (kg)	53.4	8.95	50.8	8.300	0.207
Height (m)	1.659	0.066	1.553	0.0466	0.234
BMI (kg/m^2)	19.2	2.693	21.166	3.931	0.204
Handgrip strength	67.4	2.701	45.25	3.508	0.004

[Table/Fig-1]: The anthropometrical characteristics and handgrip strength of the study sample.
p-value <0.05 considered significant.

The range values for VJT were 21-40 cm with a mean of 33.3±7.8. Moderate positive correlation was found between handgrip strength and VJT. r=0.6917 and r^2=0.4764 ($p<0.05$). The mean value of VO_2 max was 42.8±4.0 ml·kg^{-1} min^{-1} with a range of 33.7–50.9. There was a moderate positive correlation between handgrip strength and VO_2 max. r=0.7204 and r^2=0.519 ($p<0.05$). Handgrip strength and BMI were weakly correlated with each other. r=-0.1341 and r^2= 0.018 ($p<0.05$). The mean value of one minute curl-up test was 41.25±13.75 with a range between 55-24. There was a weak positive correlation between handgrip strength andone minute curls-up test. r=0.4368 and r^2=0.1908 ($p<0.05$).

DISCUSSION

The primary aim of this study was to establish grip strength as a predictor for total muscle strength. There was positive correlation found between grip strength and total muscle strength. i.e., handgrip strength was significantly associated with the performance parameters (e.g., horizontal jump and VJT), as well as with the fitness parameters (e.g., one minute curls-up and Cooper's test) [25].

However, in a study by Wang M et al., they found that grip strength, back strength and quadriceps strength were associated in healthy females. Significant positive correlation was found between

BMI range	Weight of males individuals (n=10)			Weight of females individuals (n=20)		
	Total no.	Mean weight (range)	Mean handgrip strength (range)	Total no.	Mean weight (range)	Mean handgrip strength (range)
Underweight BMI (17.05-18.00)	3	46.33 (40-48.6)	64 (60-68)	6	42 (40-45)	45.17 (40-48.6)
Normal BMI (18.5-24.9)	7	56.43 (53.4-58.3)	68.86 (65.05-70.08)	11	51.82 (48.2-55.3)	44.36 (40.5-46.8)
Overweight BMI (25.5-27.7)	0	0	0	3	65 (60.3-68.8)	48.67 (45.7-51.6)

[Table/Fig-2]: Reference chart for handgrip strength in relation to weight.

grip strength and back strength of r=0.501 and between grip strength and quadriceps strength of r=0.536 [26]. Additionally, three studies by Fraser A et al., Nicolay CW and Walker AL, and Rantanen T et al., established a positive correlation between grip strength, arm circumference and total muscle strength [27-29].

Also, two studies by Davies BN et al., and Fricke O and Schoenau E, established a significant correlation between grip strength and jumping strength [30,31]. Meanwhile in other several studies by Alvares-da-Silva MR and da Reverbel ST Bohannon RW and Kerr A et al., grip strength and physical fitness or health status were found to be quite associated with each other [32,33].

The mean values of handgrip strength were higher for males than females. In agreement with other authors, we found that boys had greater muscle strength than girls, in all BMI groups [34,35]. This can be attributed to an increase of testosterone hormone during puberty, which is a known factor to increase muscle strength. Changes in body composition and increase in total body fat in girls during puberty might add to gender related differences [36]. Patient's muscle strength according to age, gender, height and weight. Weight based references are preferred for a non-obese population. In case of obese individuals, charts based on height and age are preferred [37].

A weak correlation was found between handgrip and BMI, but when handgrip strength was compared with weight solely it was found that handgrip strength of males increased with an increase in weight in them, however it was not so with females. This variation may be possibly due to small sample size.

These studies support results of this study that handgrip strength is strongly correlated with neuromuscular and cardiovascular components of physical fitness. It suggests that handgrip strength could be a highly accurate measure to independently predict physical fitness [37]. Therefore, handgrip strength should be included in multi-dimensional health evaluation of adolescents.

Limitation(s)

The subjects are representative of a college-based sample. Further studies are needed in order to establish the validity of handgrip strength as a marker of physical fitness in individuals whose physical characteristics vary from those of our sample. The doubt remains if the involved muscles are representative for the total muscle strength. Grip strength can be used as a quick scanning method for individuals; however, it does not replace the need for a detailed assessment of an individual. So, Authors recommend to test muscle strength of several muscle groups. In patients with asymmetrical involvement or proximal muscle groups involved more compared to distal muscle groups (e.g., limb–girdle dystrophy), handgrip strength cannot be used as a sole predictive measure of total muscle strength. Moreover, in medical conditions, other markers (lipid profile, electrocardiography findings, etc.,) also need to be studied for prognosis.

CONCLUSION(S)

The present study results support the idea that handgrip strength can be an effective tool for predicting physical fitness. Handgrip strength can be employed for identifying potentially talented athletes. Moreover, through normative values of handgrip strength based on anthropometric measurements; clinicians can detect low levels of physical fitness at an early stage in order to prevent future health problems. In this way, handgrip strength could also be used as a predictive factor for health outcomes.

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PARTICULARS OF CONTRIBUTORS:
1. Assistant Professor, Department of Physiotherapy, SPB Physiotherapy College, Surat, Gujarat, India.
2. Assistant Professor, Department of Physiotherapy, SPB Physiotherapy College, Surat, Gujarat, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Shlesha Maulik Vaidya,
6/2546, Prashantam, Vaidya Street, Navsari-396445,Gujarat.
E-mail: drsmvaidya@gmail.com

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