



Hand Grip Strength in Students: Differences in the Gender Dimorphism

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DOI: <https://doi.org/10.34256/ijpefs2143>

Received: 15-09-2021, Revised: 08-10-2021; Accepted: 10-10-2021; Published: 18-10-2021

Abstract: The hands are anatomically specialized for manipulative tasks with different physical objects, where they can cope with certain loads with different forces and intensity. During various physical and sports activities, the hands produce the appropriate muscular force for gripping, which manifests as the hand grip's force. For this reason, hand grip strength (HGS) is recognized as a limiting factor in all manipulative activities performed by the cranial part of the body. The current research included a sample of 22 subjects, 16 male Body Height (BH=180.28±4.65cm); Body Weight (BW=80.05±9.96kg), Body Mass Index (BMI=24.61±2.74kg/m²) and 6 female subjects Body Height (BH=167.42±11.11cm); Body Weight (BW=64.80±10.09kg); Body Mass Index (BMI=23.02±1.57kg/m²) on the third year of study at the Faculty of Physical Education and Sports. This study aimed to determine the maximum isometric muscle force of the handgrip and differences between the same gender of students. A t-test for small samples was applied for data processing, and the relevant statistical parameters were calculated. The obtained t-test results confirmed statistically significant differences between the so-called dominant and non-dominant hands in male subjects (t=4.158; p<0.05) and female subjects (t=3.176; p<0.05). The obtained results of this research will be used for analytical and diagnostic purposes with a wide range of activities in the population of physical education and sports students (assessment of physical ability, trends, and tendencies to monitor and change abilities, influence on the implementation of certain curricula of some subjects studied at the faculty, etc.).

Keywords: Hand grip strength, Students, Dimorphism, Physical Education, Sports Students



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1. Introduction

The hand is the basic manipulative organ of the human body and the force of squeezing the hands, as a limiting factor, participates in all manipulative activities performed by the cranial part of the body [1]. The HGS test is considered the gold standard for measuring the mechanical characteristics of muscles, and is an objective method of assessing the integrity of cranial segments and represents a physiological variable that is influenced by numerous factors (age, gender, and body size). According to Carreira *et al.*, [2] it is one of the most important universal and best indicators of functional, nutritional and health status [2-4]. HGS is a general term used by athletes, and refers to the muscular strength and force they can create with their hands whose strength is estimated by dynamometry. It results in strong bending of all finger, thumb, and wrist joints with the maximum force a subject can exert under normal biokinetic conditions [5]. Also, according to Beloosesky *et al.*, [6] it is a very important component in hand rehabilitation because it often assesses the initial limitation of the patient in comparison with the valid norms. It can be used in the investigation and monitoring of patients with neuromuscular disease. The authors Gunther *et al.*, [7] consider that loss of strength is most often associated with a decrease in muscle cross-section and various degenerative changes in the joints. According to Dopsaj, *et al.*, [8], the force of hand grip is one of the most important data on contractile capacity and isometric characteristics of the value of the force that develops as a function of time. The achieved force of 100% is an indicator of the developmental capacity of the contractile potential at the level of maximum muscle contraction and is an indicator of the developmental ability of the basic explosive force of hand grip. According to Bohannon [9], hand strength is correlated with other muscle groups, including caudal limb muscles, so it is a valid indicator of a person's overall physical strength. A strong correlation between grip strength and different anthropometric properties

has been investigated by numerous authors [10-13]. Recently published reviews of the study suggest that lower levels of physical ability are associated with a higher risk of subsequent health problems. Weaker grip strength and slower walking speeds have been found to be associated with an increased risk of future bone fractures and cognitive decline during aging [14]. There is also strong scientific evidence on evolutionary and genetic relationships and patterns between the quality of hand grip strength as a suitable phenotype for identifying genetic variants relevant to the physical functioning of middle and old age [15].

Assessing hand grip strength is gaining importance in a number of situations, while in many sports this grip strength has been established as a secondary function. However, numerous studies show that arm strength is a very important component, especially in some sports: sport climbing, judo, handball, weightlifting, wrestling, tennis, field hockey, bowling, cricket, taekwondo, baseball, Nordic running, etc. [16-20]. In accordance to Koley *et al.*, [21] the dominant hand is considered to be the one that is used more often, which is faster and more precise when performing various manual tasks. The characteristics of the hand grip are relatively predictable because they are directly related to the morphological structure, degree of training, fitness, health and physiological condition at the time of testing. Dominant lateralization means the appearance of the leading limb or the leading sense when performing complex psychomotor activities, where when performing the activity, the right hand conducts bimanual activity, and the left hand follows it. Incel *et al.*, [22] confirm that the grip strength is higher in the dominant hand in right-handed people, while for left-handed people such significant differences between the parties have not been confirmed. Also, research by Dopsaj *et al.*, [23] confirms that men have a significantly higher maximum grip force in both dominant and non-dominant arms than women, due to higher muscle mass which represents higher muscle contractile potential while women show greater muscular endurance [24]. It has been proven that women perform physical work, especially by type of endurance, with greater energy efficiency, because the given mechanism is based on the phenomenon that they have a higher coefficient of respiratory exchange during submaximal exercise. Estrogen affects "fuel" metabolism during exercise in terms of glycogen savings and increases blood flow in active muscle, while the neuromuscular system of women shows a tendency to adapt more easily to changes in the level of the locomotor system [25]. The

grip strength of the right and left arms is positively correlated with weight, height, and body surface area. It has been confirmed that the grip strength of the hands significantly defines the mineral content in the bones and bone surfaces at the forearm sites and that they have a positive correlation with active body weight and physical activity [26]. From a practical point of view, the corresponding contractile characteristics of the grip strength, especially the level of maximum force, represent an indicator of the developmental ability of the basic active functional limb (arm) which represents the anatomically specialized organ of the kinetic chain end. Various authors have investigated the maximum isometric force and its dimensions [23, 27-30] in order to define the basic characteristics of the model with respect to functional and gender dimorphism at maximum isometric handshake in well-trained athletes for analytical and diagnostic purposes [17, 23, 31-34]. From the point of view of cybernetics in sports, and in order to develop methods for control and assessment of physical ability, it is necessary to define models for assessing the actual state of development of a given limb and its corresponding muscle group. These models greatly help in the classification and diagnostic definition of the development of the level or deficit of contractile ability in order to provide relevant information that influences the trainer and strategic training decisions [30]. Given the fact that students of physical education and sports are physically healthy and active population that through the study program realizes certain physical and sports activities in which there is an expression of grip strength, it was interesting to examine the maximum isometric force (handshake) in both genders and possible mutual differences in strength. The main goal of the study was to determine the maximum isometric muscle strength of the hand grip and the differences in terms of gender dimorphism of the third-year students of the Faculty of Physical Education and Sports.

2. Materials and Methods

2.1 Participants

The research included a sample of 22 subjects, 16 male (BH=180,28±4,65cm; BW=80,05±9,96kg, BMI=24,61±2,74kg/m²) and 6 female subjects (BH=167,42±11,11cm; BW=64,80±10,09kg; BMI=23,02±1,57kg/m²) on the third year of study at the Faculty of Physical Education and Sports in East Sarajevo. At the time of measurement, all were physically healthy and were familiar with the test conditions. The inclusion criteria were that there was

no restriction of movement in the upper extremities, inflammatory joint diseases or neurological disorders. The dominant hand is defined as the one that is preferred for everyday activities (writing, eating, handling heavy objects). No participants reported ambidexterity. The study was conducted with the voluntary consent of all participants. The research was conducted in accordance with the professional and ethical standards of the Declaration of Helsinki.

2.2 Study Design

The muscular force of the flexors of the fingers of the hand was measured by the method of isometric dynamometry in laboratory conditions where a standardized test - hand grip was used. The testing procedure was conducted in accordance with the defined recommendations of the American Society of Hands Therapists [35]. The force realized at maximum hand grip (dynamometry) was measured using a digital hand dynamometer CAMRY-EH101, USA (Picture 1). Dynamometry of the hand was performed by holding the subject dynamometer in one hand (bent at the elbow joint at 90°) while the other hand was resting on the thigh. The subject was then instructed to squeeze the dynamometer as tightly as possible, using the musculature of the hand. He tried to achieve the best possible result with the maximum strong grip. Each subject performed two attempts with a stronger and weaker hand, and as relevant for statistical processing, a better result was recorded. The results are expressed in kilograms (kg) with a measurement accuracy of 0.01 kg. Calibration of the instrument was performed periodically during the study.



Picture 1 CAMRY- Digital Hand Dynamometer, 200lb, EH101, USA.

2.3 Statistical analysis

Basic central and dispersion parameters were calculated for each variable. The Kolmogorov-Smirnov test was applied to confirm normality. The data were analyzed using student's T- test and statistical significance was set at level $p < 0,01$; $p < 0.05$. Statistical

procedures and analyses were conducted using the statistical package STATISTICA 10.0 for Windows (Stat Soft, Inc., Tulsa).

3. Result

Table 1 contains the basic statistical parameters of maximum hand grip strength for male and female samples, and the normality of the distribution of results was determined by K-S test, which is a prerequisite for the application of parametric statistical procedures.

The average maximum grip strength with the right hand of male students was 49.10±6.63kg, and with the left it was 46.08±6.37kg. The minimum strength achieved with the right hand is 38.30 kg, and the maximum is 61.90kg in the range of 23.60kg. The maximum achieved strength of men with the left hand is 54.10 kg, and the minimum is 35.20kg in the range of 18.90kg. CV% values of male students ranged from 13.50 to 13.82. The girls achieved an average grip strength of 35.6±4.91kg with their right hand and 31.6±3.87 kg with their left.

Table 1 Descriptive Statistics

| Variable | Gender | Mean | Min | Max | Range | SD | CV% | Skew | Kurt | K-S |
|------------------------|--------|-------|-------|-------|-------|------|-------|-------|-------|-------|
| Right hand (kg) | Male | 49,10 | 38,30 | 61,90 | 23,60 | 6,63 | 13,50 | 0,34 | -0,41 | 0,125 |
| | Female | 35,6 | 28,9 | 42,2 | 13,30 | 4,91 | 13,80 | -0,16 | -0,97 | 0,128 |
| Left hand (kg) | Male | 46,08 | 35,20 | 54,10 | 18,90 | 6,37 | 13,82 | -0,29 | -1,38 | 0,141 |
| | Female | 31,6 | 25,5 | 36,5 | 11,00 | 3,87 | 12,24 | -0,49 | 0,12 | 0,143 |

Table 2 Differences between the hand grip strength of the right and left hand of students

| | | Mean±SD | Diff. | T | df | p (2-sided) | 95% Confidence interval | |
|-------------------|------------------|------------|-------|-------|----|-------------|-------------------------|-------|
| | | | | | | | Lower | Upper |
| Male (16) | Right arm | 49,10±6,63 | 3,02 | 4,158 | 14 | 0001** | 1,462 | 4,578 |
| | Left arm | 46,08±6,37 | | | | | | |
| Female (6) | Right arm | 35,60±4,91 | 4,03 | 3,176 | 5 | 0,025* | 0,768 | 7,298 |
| | Left arm | 31,57±3,86 | | | | | | |

Note **p<0,01, *p <0.05

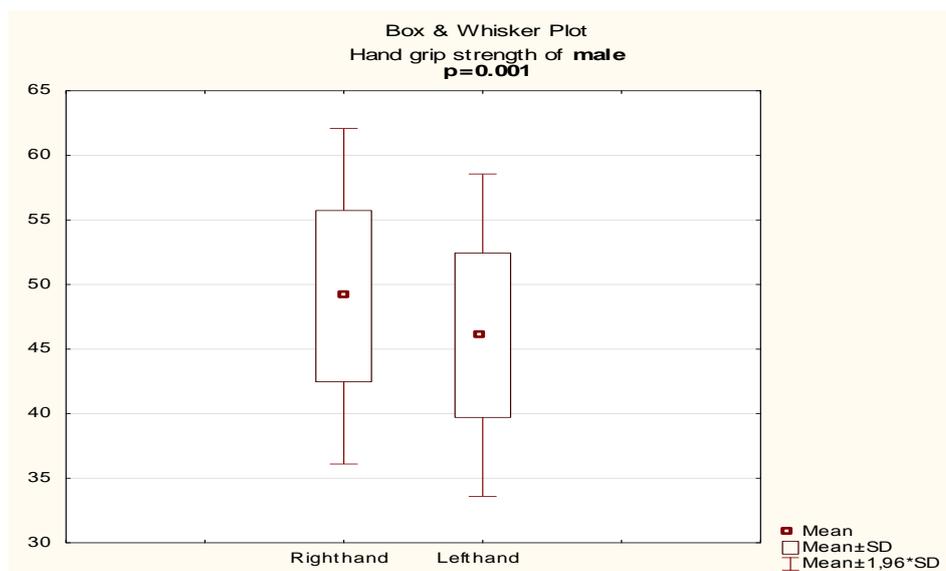


Figure 1 Differences between right and left hands- Male

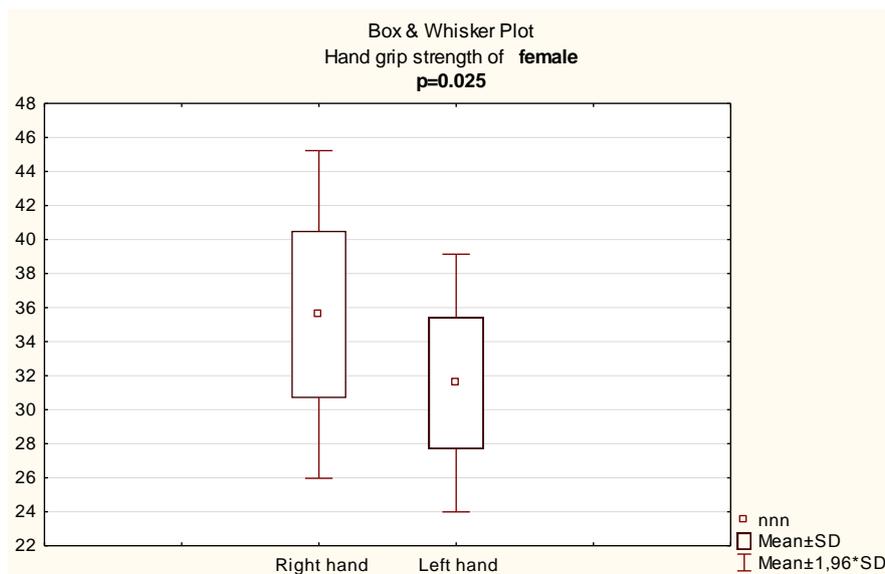


Figure 2 Differences between right and left hand-Female

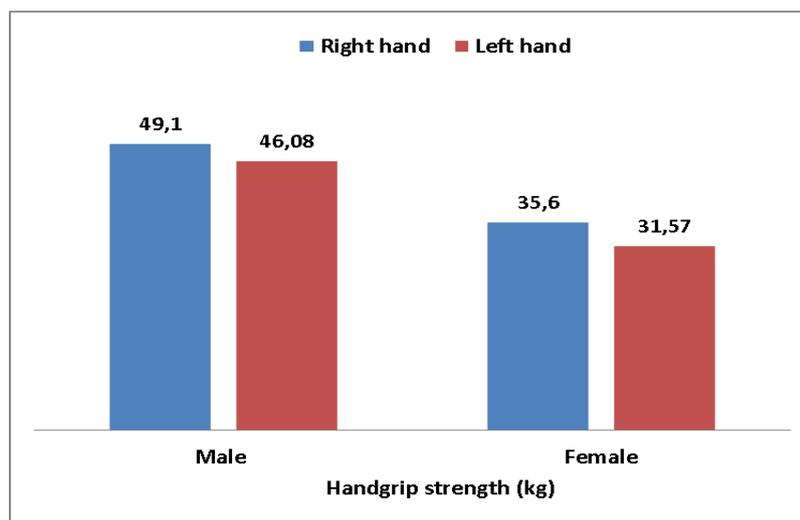


Figure 3 Differences of average values hand grip strength (same gender)

The maximum achieved strength with the right hand was 42.2kg, and the minimum was 28.9 kg. The strength of the left arm of the female sample, as in flies, was lower on average, so the maximum grip strength was 36.5 kg and the minimum of 25.5 kg with a CV% of 12.24 to 13.80 (Table 1). In general, all results (average, maximum and minimum values) of strength were higher in male subjects than in female subjects, as expected. Also in both subsamples, the right hand (dominant) proved to be stronger than the left. Table 2 contains the results of the T-test for both subsamples of subjects. Based on the obtained T-test results, it can be concluded that statistically significant differences were recorded in the maximum grip strength between the left and right arm of male students ($t=4.158$, $p<0.001$) and between the grip

strength of female students ($t=3.176$, $p<0.025$) (Fig. 1, 2, 3).

4. Discussion

For optimal hand function, it is necessary to preserve the range of motion in all joints of the upper extremity, the contractile ability of the muscles, endurance, as well as the function of the grip. Due to the fact that the hands are anatomically predetermined for various manipulative tasks, where during various physical and sports activities they produce the appropriate muscular force for gripping, which is manifested as hand grip force, therefore hand grip force is often recognized as a limiting factor in all manipulative activities realized by the cranial part of the body [1]. Muscle strength is an important aspect of

physical fitness and health, where any decrease in muscle strength causes significant functional limitations. The dominant hand is considered to be the one that is used more often, it is faster and more precise when performing manual tasks, and the optimal range of motion in all joints of the upper extremity, contractile ability of muscles, endurance, as well as grip functions. Dominant lateralization means the appearance of the leading limb when performing complex psychomotor activities, and most often dominant lateralization appears as right-handed. According to Koley, *et al.*, [21], hand grip characteristics are relatively predictable because they are directly related to morphological structure, training, fitness, health, and physiological condition at the time of testing. The subject of the current research involves the examination of the contractile characteristics of the hand as the basic manipulative organ with the main goal of the study to determine the maximum isometric muscle force of the hand grip and the difference in terms of full dimorphism of students. The obtained T-test results confirmed statistically significant differences between the so-called dominant and non-dominant hands between male subjects ($p < 0.001$) and between female subjects ($p < 0.025$), thus confirming significant dimorphism in both genders. The distribution of the results of the average values (Figure 3) partially confirms the "10% rule", which implies that the strength of the dominant hand is 10% higher than the strength of the non-dominant hand [36]. Similar results to our study were obtained by Koley, & Mahendra [5] who, among other anthropometric parameters, analyzed the grip strength of a cricketer's hand, and the results obtained served as criteria in the selection of candidates for this sport. The obtained results of our study, although on a smaller sample, are in line with the results of previous research [12, 13, 23, 36] that analyze anthropometric characteristics, where hand grip proved to be an indicator of the different anthropometric profile of the subjects. In terms of grip dominance and differences within the same gender, the results of this study confirm the dominance of right-handed people over left-handed ones, which supports previous research on this topic [21], as well as questions differences between the grip strength of subjects from urban and rural areas [37].

In our female sample, the maximum grip force of the left hand is $31.57 \text{ kg} \pm 3.86 \text{ kg}$ and the right hand $35.60 \pm 4.91 \text{ kg}$, which is slightly higher than in the study of Kljajić, *et al.*, [38] where the maximum grip force of the left hand grip was 28.72kg and right was 31.47kg, i.e. the research of Dopsaj, *et al.*, [39] where

the maximum grip force of the left hand was 28.40kg and for the right hand it was 31.10kg. Comparing the results between male subjects and both studies, it is found that our subjects had a stronger grip with the left (46.08 kg) and right hand (49.10 kg). This result is perhaps expected because our respondents are mostly active in sports activities and have a stronger hand grip than the respondents from the previous research, who may be expected to have a higher level of physical abilities, since they are students of the Criminal Police Academy.

The assessment of hand grip strength and endurance is applied in various areas of sports research. In the field of anthropometric measurements, hand grip characteristics are often compared and correlated with other physical characteristics, body height, BMI, and age [40, 41]. In a large number of studies, the application of hand grip strength can be found in various sports, both in recreational and top athletes [34]. It is also important in monitoring physical and social factors in relation to the environment [41, 42] and as a measure of aggression and social competition among adolescents [43].

During life, arm strength develops in both genders, reaching a peak at 35 years of age and continuously decreasing, while the process of maturing limb dominance in the manipulative field ends somewhere between 6 and 8 years of age [38]. Anthropometric variables (forearm circumference and length, arm size, body weight) show a positive correlation with grip strength, while body mass index, type of work and hand dominance show only partial positive correlation or no correlation with grip strength [7]. These allegations are partly consistent with the results of a current study that recorded significant gender differences that are more pronounced in male students which is also consistent with some earlier research [2]. This distribution of our results is a consequence of the different body status of individuals of both genders, where body mass, height, individual longitudinal proportions, etc. are sometimes defined as the decisive factor in the grip strength of the hand [4, 7, 11, 44]. Our research has shown that in female subjects, the dominant hand is stronger than the non-dominant hand, which is in line with the above rule. In male respondents, this difference is smaller. In the research [45] it was found that the dominant hand in left-handed people is stronger than the non-dominant one by 11.2%, while the dominant hand in right-handed people is only 2.4% stronger than the non-dominant hand. A smaller difference in hand grip force

between the right and left arm can also be found in other studies [46, 47] where the non-dominant arm is weaker than the dominant by 0.1-3%. Allegations about the possible influence of morphological parameters on the grip strength justify the results of our study because our sample consists of students of physical education and sports, where each sport requires a certain morphological profile of an individual, hence the level of necessary strength. According to Chatterjee *et al.*, [26] the grip strength of the right and left arm is positively correlated with weight, height and body surface area and is a significant determinant of bone mineral content and bone surface at the forearm sites thus achieving a positive correlation with lean body mass and physical activity. Some previous research Fry *et al.*, [48] confirms that one's grip strength plays a key role in injury prevention and the overall development of physical strength and physical performance [49], while the contractile abilities of the hand muscles are of great importance in predicting functional limitations, motor disorders and are a good indicator of overall strength, so they can be used as early screening in detecting the danger of physical disability [38].

5. Conclusion

The research included the physically active population of physical education and sports students with the aim of analyzing possible differences in the gender dimorphism of students. The results confirmed significant differences of both subsamples between the dominant and non-dominant hand (male, $p < 0.001$; female, $p < 0.025$). The obtained results of this research will be used for analytical and diagnostic purposes with a wide range of activities in the population of physical education and sports students (assessment of physical ability, trends and tendencies to monitor and change abilities, influence on the implementation of certain curricula of some subjects studied at the faculty, etc.). This is the first research on this topic with students of physical education and sports. Next study, it would include a significantly larger sample of respondents, which would allow obtaining more significant conclusions.

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Funding

No funding was received to carry out this study

Authors Contribution

Both the authors equally contributed to this work. Both of them read and approved the final version of the draft.

Ethics Approval

Approval was sought from the institution ethics committee.

Informed Consent

Written consent was obtained from the participants

Conflict of interest

The Authors have no conflicts of interest to declare that they are relevant to the content of this article.

Does this article screened for similarity?

Yes

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