Теорія та методика фізичного виховання
Physical Education Theory and Methodology
Teorìâ ta Metodika Fìzičnogo Vihovannâ

ISSN 1993-7989 (print)
ISSN 1993-7997 (online)
ISSN-L 1993-7989

ORIGINAL SCIENTIFIC ARTICLE

# AN ASSESSMENT OF MAXIMAL ISOMETRIC HAND GRIP STRENGTH AND UPPER BODY EXPLOSIVE STRENGTH AND ENDURANCE IN VARIOUS BALL SPORTS

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Accepted for Publication: December 16, 2023
Published: December 22, 2023

**DOI: 10.17309/tmfv.2023.6.16**

**Abstract**

**Background.** Playing with the ball and using hand-arm strength and power are very crucial for ball game players. It takes arm force and endurance, as well as isometric hand grip strength, to accomplish ball-game skills.

Study purpose. The aim of the study was to evaluate maximal isometric hand grip strength, arm and shoulder explosive strength, and endurance in basketball, handball, and volleyball athletes.

**Materials and methods.** The study randomly selected 135 male athletes, including 45 basketball, 45 handball, and 45 volleyball players, aged 17 to 24, all competing at the inter-university level. Hand grip strength (HGS) for both dominant (DHGS) and non-dominant (NDHGS) hands was measured using a JAMAR hydraulic hand grip dynamometer. An over-the-head seated medicine ball throw (SMBT) test assessed explosive arm strength, while a push-up (PU) test evaluated muscular strength and endurance.

**Results.** The F-values (F) (2, 132) of DHGS, NDHGS, SMBT, and PU tests among basketball, handball, and volleyball players were 0.499 ($p = 0.608$); 1.166 ($p = 0.315$); 5.595 ($p = 0.005$); and 10.339 ($p = 0.000$), respectively. The results indicated that no notable distinctions were observed in DHGS and NDHGS among athletes in the three sports. However, considerable differences were found in the SMBT and PU tests.

**Conclusions.** The study concluded that basketball, handball, and volleyball players' maximum isometric hand grip strength was nearly the same, but in both cases, the handball player's mean value was superior to others. Upper-body explosive power, muscular strength, and endurance showed distinct differences from one group to another.

**Keywords:** hand grip strength, hand dynamometer, upper-body explosive power, muscular strength and endurance, ball sports.

## Introduction

The term "ball game player" describes athletes who participate in sports where a ball is the main object of play. Basketball, handball, volleyball, soccer, baseball, rugby, cricket, hockey, and a host of other sports can be considered among these. Players of these games often compete alone or in teams, aiming to win points by strategically moving the ball while adhering to the rules and regulations of their chosen game. In ball games, players need significant arm strength, endurance, and a strong hand grip to effectively engage in play. These abilities are crucial for executing a variety of movements such as serves, throws, spikes, blocks, and tackles, which demand not only strength but also endurance in the arms and a strong isometric grip (Reichert et al., 2023). Moreover, both everyday activities and several sports necessitate strong, concentrated contractions of the forearm and hand flexor muscles (Ziyagil et al., 2015).

Handgrip strength is the maximum force when someone voluntarily clasps their fingers together, usually measured in standard conditions with a normal range of motion (Richards et al., 1996; Bohannon, 1997; Gandhi et al., 2010). An individual's muscular strength can be estimated by one's handgrip strength (Foo et al., 2007; Ling et al., 2010). It is one of the most accurate clinical methods for assessing strength and is considered an important indicator of general health (Häger-Ross & Schieber, 2000; Groslambert et al., 2002). Additionally, it's effective in assessing upper limb muscle strength, serving as a useful predictor of muscle strength and

endurance (Nara et al., 2022; Vaidya & Nariya, 2021). Handgrip strength is crucial for catching, throwing, and passing the ball in various team sports. Fingers will also spread less widely when they are longer and the surface material of the hand is greater than what is needed to grasp an object (such as a ball), making grasping more efficient and less tiring (Nag et al., 2003). So, all ball sports demand hand grip strength to hold an object, a ball, or an opponent. Theoretically, players with outstretched fingers and a large flat hand may also have stronger grip strength (Visnapuu & Jürimäe, 2007). The ability to grasp objects firmly is employed as a measure of general physical strength and a practical indicator of physical perfection. This form of energy is influenced by various physiological metrics such as age, sex, exercise, and physical dimensions (Jayanthi, 2018). As isometric tests only require a single maximal contraction and relatively basic equipment, they are simple to carry out. Due to the requirement of an adequate level of grip strength in sports like handball, volleyball, tennis, and basketball, the evaluation of handgrip strength is of the utmost importance (Khanna & Koley, 2020). Hand morphology and functional characteristics may have a significant role in the performance of ball games where the use of the hand is important (Barut et al., 2008). Researchers Borges Junior et al. (2009) suggest that maximal isometric grip strength (Fmax) serves as a useful metric for contrasting different sports disciplines and for distinguishing between dominant and non-dominant hands.

The medicine ball throw test is performed to measure an athlete's upper body explosive power, strength, and coordination of their core, upper limb, and trunk muscles, which are necessary to generate the force and speed required for throwing, shooting, passing, hitting, or spiking. The Seated Medicine Ball Throw (SMBT) test is widely used to evaluate bilateral upper body strength and power across various populations. It has been utilized in research involving male athletes (Read et al., 2013; Santos & Janeira, 2012; Stockbrugger & Haennel, 2003), female athletes (Cronin & Owen, 2004; Jones, 2014), older athletes (Harris et al., 2011), as well as college and university students (Clemons et al., 2010; van den Tillaar & Marques, 2013). Additionally, it is a useful tool for assessing healthy, non-athletic individuals (Vossen et al., 2000). Researcher Suntharalingam et al. (2022) suggest that combining medicine ball exercises with regular training can notably enhance both physical and basketball-specific skills. It is a convenient, affordable, and low-tech tool that can be used to monitor athletes on the field to discover talent and anaerobic power (Kumar et al., 2021a). This test serves as a valuable tool for evaluating upper-body explosive ability, providing insight into how an athlete performs in this particular aspect. The push-up test (arms 90º angle) is widely employed to assess the durability and stamina of the arms and upper body muscles (Yıldırım et al., 2022; Kellner et al., 2021; Baumgartner et al., 2002). To build pectoralis major and triceps brachii strength for athletic exercise and performance, perform push-ups as a strength exercise (Cogley et al., 2005; Mayhew et al., 1991). The chest, shoulders, triceps, and core are all muscles that are worked with push-up, a simple bodyweight exercise. Success in various ball sports, including basketball, handball, and volleyball, depends on upper body strength, muscular endurance, and stability. This test involves measuring how many push-ups a person can do within a certain time frame. In evaluating sports performance, push-up tests are of significant importance.

Overall, hand grip strength, upper body explosive power, and push-up exercises are integral to enhancing performance in various ball sports such as basketball, handball, and volleyball. These games are similar in nature and style of play, as hand strength, arm and upper body strength, and endurance are used similarly. Due to similar practice and training opportunities, university-level athletes in these three sports probably have comparable grip strength, explosive power, and endurance. Therefore, the present study compares hand, arm, and upper body function in different university level ball sports, specifically basketball, handball, and volleyball. The function of the hand was assessed through hand grip strength, while tests involving the medicine ball throw and push-ups measured arm strength, upper body explosive strength, and endurance.

## Materials and Methods

### *Participants*

A total of one hundred thirty-five (N=135) male athletes were randomly selected for this study, among them (n=45) basketball players, (n=45) handball players, and (n=45) volleyball players. The subjects were between the ages of 17 to 24, and at least they had competed in their respective sports at the inter-university competition. All the participants (subjects) were chosen from ten public universities in Bangladesh.

**Table 1.** Differences data (mean ± SD) and ANOVA of the subjects

| Variables | Basketball (n=45) | Handball (n=45) | Volleyball (n=45) | ANOVA |
|---|---|---|---|---|
| Age (yrs) | 22.04±1.21 | 21.69±1.68 | 21.82±1.85 | 0.569 |
| Height (cm) | 177.78±6.75 | 170.44±6.37 | 174.26±7.08 | 0.000* |
| Weight (kg) | 71.84±6.75 | 66.41±7.87 | 68.03±8.66 | 0.004* |
| BMI (kg/m$^2$) | 22.72±1.65 | 22.82±1.92 | 22.38±2.35 | 0.558 |

BMI = body mass index; *= significant difference at 0.05 level

### *Instruments*

For anthropometric measurements of height and weight, a KRUPS stadiameter (India) and an OMRON digital weighing scale (India) were used. The BMI was then determined using the following formula: weight (kg)/height(m)$^2$. The maximal isometric DHGS and NDHGS were measured with the help of a JAMAR (USA) hydraulic hand grip dynamometer. Upper body (arms) strength and explosive power were measured for the SMBT (MDBuddy medicine ball, China) test, and muscles strength and endurance were assessed using the PU test.

### *Procedure*

### *DHGS and NDHGS tests*

The maximal isometric grip strength of the DHGS and NDHGS were measured with the help of a JAMAR (Model

J00105) hydraulic hand dynamometer (Lafayette Instrument, Lafayette, IN, USA) (Hepping et al., 201). For this test, the subject was seated comfortably on a chair with his back straight, abduction and flexion of the shoulder and elbow were 0° and 90°, respectively. Then the subject was asked to use a comfortable grip position (second handle position) and proper technique for the grip strength measurements. As soon as everyone is seated correctly, say, squeeze as firmly as you can—harder!—harder!—then relax. The peak-hold needle automatically recorded his highest exerted force. Before taking new readings, reset the peak-hold needle to zero (Dynamometer, 2004). Tests were taken in the sequence of dominant hand followed by non-dominant hand, and the time interval between the two tests was 30 seconds. As the final score, the mean of the three trials was used, which is in kilograms.

### *SMBT test*

Upper limb explosive strength was measured through an SMBT (MDBuddy; Nantong Modern Sporting Industrial Co., Ltd., Jiangsu, China) test. The medicine ball is a round shape made of rubber, and the gripping surface is very good. For this, a 2-kg medicine ball is required, and the subject was seated comfortably on the chair with his upper body erect and both legs touching the ground. Subjects were asked to warm up properly, lift the medicine ball up with both hands, and throw the ball forward with maximum force (like a football throw-in). During this time, the body cannot be moved backwards or forwards, and of course, the body is against the back of the chair. The horizontal distance was measured in meters between where the base of the chair begins and the bottom of the throw. A total of three throws were made, and there was a one-minute break in between. Arm strength and explosive power were obtained by measuring the highest distance in meters.

### *PU test*

Arm and shoulder muscle strength and endurance were measured using the push-up test, which requires the muscles to perform rapid, repetitive movements for a specified period of time. To begin the test, the subjects place both palms on the floor with shoulders extended, elbows straight, and the lower back (knees) straight. As the time started, the subject was touching his body towards the floor until the elbows were at 900. Repeat fast until the 30 seconds are up. A Casio Digital Stopwatch (Casio Electronics Co., Ltd., China) was used for recording time, and the total number of push-ups was counted.

### *Statistical analysis*

Statistical evaluation was performed using IBM's SPSS version 20 for Windows, located in Chicago, IL, USA. Descriptive metrics were calculated for each group. To detect significant differences in data, one-way ANOVA, LSD post-hoc analysis and independent t-test were employed with significance level set at 0.05. Levene's test was utilized to assess the homogeneity of variances, which confirmed normal data distribution.

## Results

Table 3 indicates that the observed differences were not statistically significant between groups for variables such as DHGS ($F_{(2, 132)} = 0.499$, $p = 0.608$), and NDHGS ($F_{(2, 132)} = 1.166$, $p = 0.315$). In the study, the DHGS and NDHGS of basketball, handball, and volleyball players were about the same, but in two cases, the handball player's average value was higher than the others. The data revealed a significant difference between groups for the given variables, namely, SMBT and PU tests ($F_{(2, 132)} = 5.595$, $p = 0.005$), and ($F_{(2, 132)} = 10.339$, $p = 0.000$), respectively.

The post-hoc (LSD) test showed that the SMBT test was statistically significant difference between the handball ($6.2347 \pm 0.74198$, $p = 0.035$) and basketball ($5.8760 \pm 0.90564$, $p = 0.035$) groups as compared to the volleyball ($5.6789 \pm 0.73829$). Again, there was a statistically significant difference between handball and volleyball ($p = 0.001$); and no significant difference between basketball and volleyball ($p = 0.244$). For the PU test, the basketball, handball, and volleyball groups were all statistically significantly different ($p = 0.017$; 0.035; 0.000), respectively.

**Table 2.** Descriptive statistics

| Variables | Players | N | Mean | Std. Dev. | Std. Error | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| DHGS (kg) | Basketball | 45 | 48.3971 | 8.12343 | 1.21097 | 28.33 | 74.00 |
| | Handball | 45 | 49.4191 | 7.21703 | 1.07585 | 35.33 | 70.33 |
| | Volleyball | 45 | 47.8933 | 6.73616 | 1.00417 | 33.66 | 64.33 |
| NDHGS (kg) | Basketball | 45 | 46.5738 | 8.98924 | 1.34004 | 26.33 | 71.33 |
| | Handball | 45 | 47.4636 | 8.31380 | 1.23935 | 30.00 | 68.00 |
| | Volleyball | 45 | 44.8709 | 7.14454 | 1.06504 | 31.33 | 60.66 |
| SMBT (m.) | Basketball | 45 | 5.8760 | 0.90564 | 0.13500 | 4.10 | 7.97 |
| | Handball | 45 | 6.2347 | 0.74198 | 0.11061 | 4.82 | 8.25 |
| | Volleyball | 45 | 5.6789 | 0.73829 | 0.11006 | 4.17 | 7.00 |
| PUT(No.) | Basketball | 45 | 26.311 | 60.4976 | 0.9686 | 17.0 | 42.0 |
| | Handball | 45 | 29.911 | 7.5342 | 1.1231 | 14.0 | 46.0 |
| | Volleyball | 45 | 23.133 | 7.1529 | 1.0663 | 10.0 | 40.0 |

**Table 3.** One-way ANOVA of selected parameters of basketball, handball, and volleyball players

| Variables | Groups | Sum of Squares | df | Mean Square | F-ratio | p-value |
|---|---|---|---|---|---|---|
| DHGS | Between Groups | 54.394 | 2 | 27.197 | 0.499 | 0.608 |
| | Within Groups | 7191.867 | 132 | 54.484 | | |
| NDHGS | Between Groups | 156.202 | 2 | 78.101 | 1.166 | 0.315 |
| | Within Groups | 8842.677 | 132 | 66.990 | | |
| SMBT | Between Groups | 7.146 | 2 | 3.573 | 5.595 | 0.005 |
| | Within Groups | 84.295 | 132 | .639 | | |
| PUT | Between Groups | 1034.948 | 2 | 517.474 | 10.339 | 0.000 |
| | Within Groups | 6606.489 | 132 | 50.049 | | |

*. Significant at 0.05 level

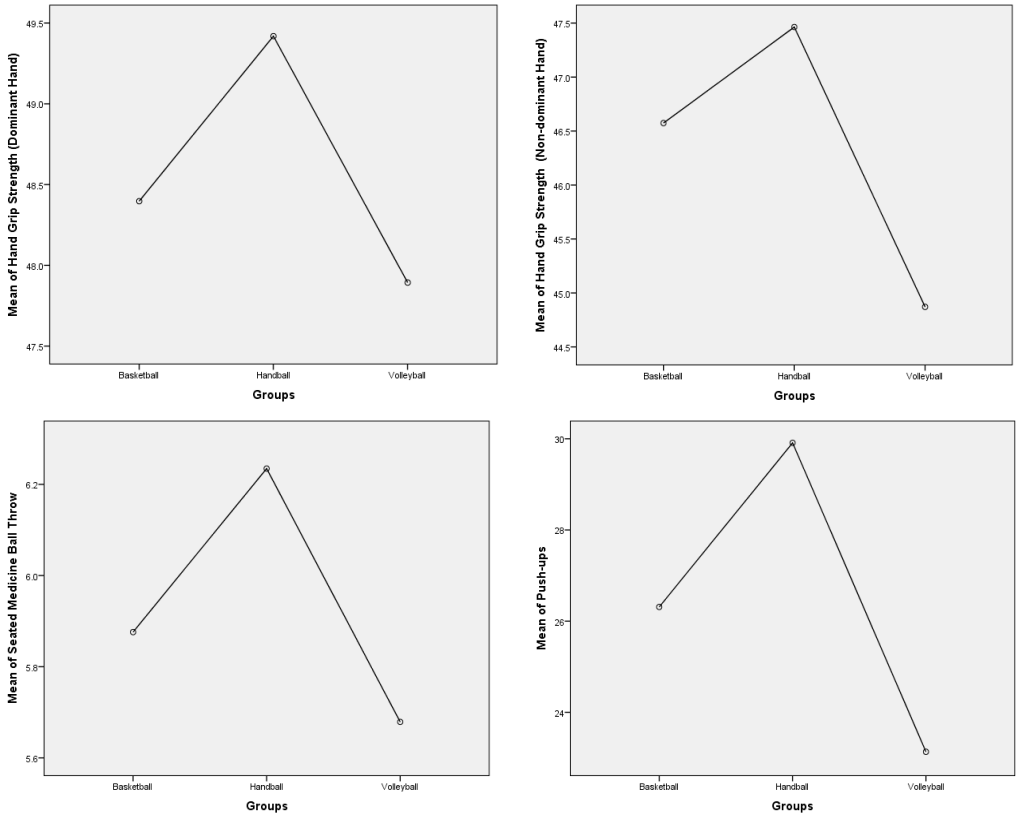


**Fig. 1.** Mean plots of variables in three groups

**Table 4.** Post-hoc (LSD) test

| Variables | Groups | Groups | Mean Diff. | Std. Error | Sig. Level |
|---|---|---|---|---|---|
| SMBT | Basketball | Handball | -0.35867* | 0.16847 | 0.035 |
| | | Volleyball | 0.19711 | 00.16847 | 0.244 |
| | Handball | Basketball | 0.35867* | 0.16847 | 0.035 |
| | | Volleyball | 0.55578* | 0.16847 | 0.001 |
| | Volleyball | Basketball | -0.19711 | 0.16847 | 0.244 |
| | | Handball | -0.55578* | 0.16847 | 0.001 |
| PU | Basketball | Handball | -3.6000* | 1.4914 | 0.017 |
| | | Volleyball | 3.1778* | 1.4914 | 0.035 |
| | Handball | Basketball | 3.6000* | 1.4914 | 0.017 |
| | | Volleyball | 6.7778* | 1.4914 | 0.000 |
| | Volleyball | Basketball | -3.1778* | 1.4914 | 0.035 |
| | | Handball | -6.7778* | 1.4914 | 0.000 |

*. The mean difference is significant at the 0.05 level

Independent t-tests revealed a significant difference in the strength of hand grip between DHGS and NDHGS in basketball, handball, and volleyball players: t(268) = 2.392, sig. = .017 (2-tailed), p<0.05. However, DHGS was higher among the three groups.

## Discussion

According to the table 3 analysis, no significant difference was obtained in DHGS and NDHGS among basketball, handball, and volleyball players. Likewise, researcher Barut et al. (2008) conducted a study on handgrip strength across different sport groups. The results revealed that there was no noteworthy variation in the grip strength of the left and right hand among male participants engaged in basketball, handball, and volleyball. Similarly, Çolak (1995) evaluated male athletes in volleyball, basketball, and football, and the findings indicated that soccer players exhibited the highest

**Table 5.** Independent t-test between DHGS and NDHGS of three groups together

| Item | Parameters | Mean (kg) | Std. Deviation | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|
| Hand Grip Strength | DHGS | 48.5699 | 7.35368 | 2.392 | 268 | 0.017 |
| | NDHGS | 46.3027 | 8.19486 | | | |

Significant at 0.05 level

grip strength in both hands. However, differences in grip strength between groups did not reach statistical significance for other sports. In a study by Yüksel (2017), the grip strength of male Turkish basketball players across different leagues was analyzed. The findings indicated no notable difference in the grip strength of the right and left hands between the two leagues. Based on the research's Kararkoç et al. (2015) findings, it can be said that athletes who participate in various sports, including judo, badminton, handball, basketball, and football, have the same grip strength in both the left and right limbs. Also, athletes in volleyball, basketball, table tennis, and tennis all have similar average left hand grip strengths (Duran, 2021). According to Fallahi and Jadidian (2011) conducted a study on grip athletes in sports such as basketball, handball, volleyball, and wrestling, where grip strength is important, and found that they had more dominant and non-dominant hand grip strength than those not involved in any athletic activity. Similar studies were done by other sports and subjects, and the results suggest that there is no major disparity in dominant and non-dominant hand grip strength in field hockey players (Koley & Kaur, 2017), male elite and sub-elite weightlifters (Erdağı, 2020), and athletes from various sports like hockey, tennis, badminton, cricket (Joseph et al., 2021), basketball, and netball (Kumar et al., 2021b). Researcher Eler and Eler (2018) found no statistical difference between right-hand and left-hand grip strength in four disciplines of male racket sports (tennis, squash, table tennis, and badminton). A six-pound medicine ball throw was used to demonstrate that basketball players' arms have more explosive strength than volleyball players' arms (Suma & Giridharaprasath, 2022). In another study, compared to volleyball players, handball players had higher shoulder strength in their unilateral and bilateral seated medicine ball throwing ability (Saccol et al., 2022). Muscular endurance showed a notable variation between university-level basketball and handball players when measuring muscle strength through the push-ups test (Pandian & Divya, 2022). The data in Table 5 indicates that there are meaningful statistical variances in grip strength between the DHGS and NDHGS across all three groups, with the dominant hand always exhibiting greater strength. Prior research that included both right- and left-handed participants also demonstrated that the dominant hand had a notably stronger grip in all evaluations, corroborating earlier findings (Armstrong & Oldham, 1999; Incel et al., 2002). Grip strength is significantly different between the dominant and non-dominant hands of male and female athletes in basketball, handball, volleyball, and badminton (Kaplan, 2016). In a study by Massuça et al. (2014) between premier and non-premier handball athletes, the preferred hand exhibited noticeably more powerful grip strength (2.15 kg difference, $p < 0.05$). Handgrip strength was measured in 544 young Italian adults (18–30 years) in relation to handedness, and the results showed that dominant hands had higher HGS than non-dominant hands, and ambidextrous individuals had a stronger right hand (Zaccagni et al., 2020).

In summary, handball is a physically demanding contact sport that relies heavily on the upper body, hands, and arms for both offensive and defensive aspects. Players use their bodies to connect with opponents, requiring substantial upper body strength for effective technique. Defenders in handball engage in physical battles, relying on their upper body strength to push, block, and intercept opponents. Explosive power generated by the upper body is crucial for powerful throws and scoring opportunities. In this research, it is observed that handball distinguishes itself from less contact-based sports such as basketball and volleyball.

## Conclusions

The findings of the research showed that the peak isometric grip strength among athletes in basketball, handball, and volleyball was fairly comparable. Nevertheless, handball players demonstrated superior average grip strength compared to those in the other two sports. Additionally, there were notable disparities in areas like upper-body explosive force, muscle strength, and endurance between the groups. These variations highlight the distinct physical attributes and training regimes across these three sports.

## Acknowledgment

The authors express their gratitude to all participants who contributed to the study.

## Conflicts of interest

The authors declare no conflicts of interest.

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# ОЦІНКА МАКСИМАЛЬНОЇ ІЗОМЕТРИЧНОЇ СИЛИ СТИСНЕННЯ КИСТІ ТА ВИБУХОВОЇ СИЛИ ВЕРХНЬОЇ ЧАСТИНИ ТІЛА Й ВИТРИВАЛОСТІ В РІЗНИХ СПОРТИВНИХ ІГРАХ ІЗ М'ЯЧЕМ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 8 с., 5 табл., 1 рис., 53 джерела.

**Історія питання.** Гра з м'ячем і використання сили й потужності кистей і рук дуже важливі для гравців в ігри з м'ячем. Для вдосконалення навичок гри з м'ячем потрібна сила та витривалість рук, а також ізометрична сила стиснення кисті.

**Мета дослідження.** Метою цього дослідження було оцінити максимальну ізометричну силу стиснення кисті, вибухову силу рук і плечей, а також витривалість у баскетболістів, гандболістів і волейболістів.

**Матеріали та методи.** Для участі в дослідженні були випадковим чином відібрані 135 спортсменів чоловічої статі, у тому числі 45 баскетболістів, 45 гандболістів і 45 волейболістів, віком від 17 до 24 років, які всі беруть участь у змаганнях на міжуніверситетському рівні. Силу стиснення кисті (HGS) як для домінантної (DHGS), так і для недомінантної (NDHGS) руки вимірювали за допомогою гідравлічного ручного динамометра JAMAR. Для оцінки вибухової сили рук використовували тест на кидок медичного м'яча через голову з положення сидячи (SMBT), а для оцінки м'язової сили та витривалості використовували тест на віджимання (PU).

**Результати.** Значення F-величин (F) (2, 132) тестів DHGS, NDHGS, SMBT та PU серед баскетболістів, гандболістів і волейболістів становили 0,499 (p = 0,608); 1,166 (p = 0,315); 5,595 (p = 0,005); та 10,339 (p = 0,000) відповідно. Результати показали, що жодних помітних відмінностей у тестах DHGS та NDHGS серед спортсменів у всіх трьох видах спорту не спостерігалося. Проте в тестах SMBT та PU були виявлені значні відмінності.

**Висновки.** На підставі результатів дослідження зроблено висновок, що максимальна ізометрична сила стиснення кисті в баскетболістів, гандболістів і волейболістів була приблизно однаковою, але в усіх випадках середнє значення гандболістів було вищим, ніж в інших. Показники вибухової сили верхньої частини тіла, м'язової сили та витривалості показали чіткі відмінності в різних групах.

**Ключові слова:** сила стиснення кисті, ручний динамометр, вибухова сила верхньої частини тіла, м'язова сила та витривалість, спортивні ігри з м'ячем.

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**Cite this article as:** Rahman, Md. H., & Sharma, J. P. (2023). An Assessment of Maximal Isometric Hand Grip Strength and Upper Body Explosive Strength and Endurance in Various Ball Sports. *Physical Education Theory and Methodology, 23*(6), 932-939. https://doi.org/10.17309/tmfv.2023.6.16

Received: 10.11.2023. Accepted: 16.12.2023. Published: 22.12.2023