Correlation Between Handgrip Strength and Shoulder Torque in Egyptian Tennis Players

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ABSTRACT

Background: Shoulder stability is very important for distal mobility and this concept may affect the performance of tennis players. Shoulder rotators have important role in shoulder joint stability. **Purpose of the study** was to investigate the correlation between shoulder torque and hand grip strength in Egyptian tennis players. **Subjects:** Eighty-four players from both genders with age ranging from 17 to 25 years, weight ranging from 57 to 82 kg, height ranging from 162 to180 cm, BMI ranging from 21 to 27 kg/m^2, were assigned to one equal group. **Methods:** Hand grip dynamometer was used for measuring grip strength and isokinetic system was used for measuring shoulder torque for internal and external rotators. **Results**: There was significant correlation between hand grip strength and shoulder internal rotators' peak torque ($r = 0.81$, $p = 0.0001$) and significant correlations between hand grip strength and shoulder external rotators' peak torque ($r = 0.89$, $p = 0.0001$).

Conclusion: There was a significant correlation between hand grip strength and shoulder torque in tennis players.

Keywords: Hand grip, Shoulder torque, Tennis players.

INTRODUCTION

There is a relationship in healthy subjects between Hand grip strength (HGS) isometric strength and isokinetic moment produced by external shoulder rotators and abductors and elbow flexors. It has been suggested that isometric HGS can be used to monitor isokinetic strength of some muscle groups that contribute to shoulder joint stability including lateral rotators (1).

Upper extremity function allows for complex task accomplishment in reaching, prehension, and manipulation. The upper extremity can be examined as a linkage system. The main effector of the upper extremity is the hand; the wrist, elbow, and shoulder act to place the hand in space (2).

The shoulder internal rotation (IR) and external rotation (ER) play a very important role in the stability of the glenohumeral joint and the kinematics of overhead throwing. From the acceleration phase of throwing, the arm is whipped from the position of extreme external rotation to one of internal rotation (3).

Proximal stability for distal mobility is a concept that has been referred to the simple task of gripping can have a great influence on the shoulder (6). Not only has it been shown to improve rotator cuff (RTC) activity, but it may have an important role in injury prevention and recovery (4).

The lack of proximal stabilization may limit the ability of subjects to exert maximum effort. In turn, this may limit hand muscle strength. A strong correlation between hand grip strength and lateral rotator strength was shown in all positions of the left and right hands, suggesting that assessment of hand grip strength can be used to monitor RTC recruitment function (5).

Previous study has shown a positive correlation between hand gripping activity and rotator cuff muscle activity. This correlation has been shown to be a result of a neurological connection through propriospinal pathways. An advantage of this mechanism is that it provides the shoulder with anticipatory stability in upper extremity tasks involving a gripping activity (6).

Irradiation has proven to be of great benefit in improving stability.

Irradiation has been defined as "a spreading and increased strength of a response". Gripping can be used to increase the flow of neural drive to all of the muscles in the extremity. This can lead to increased stability and strength of the entire upper quarter (7).

The origin of the concept of proximal stability for distal mobility is often attributed to proprioceptive neuromuscular facilitation (PNF) developed by Kabat and Knott in the late 1940's and does appear in reference to evaluating and treating the trunk stating that "in an efficient state the trunk provides appropriate proximal stability or controlled mobility to support optimal task or postural performance" (8).

Handgrip strength plays an important role to predict the performance in various sports activities especially in Baseball game, racket games, and in cricket. Strength can be explained as the maximal force of the muscle or muscle group. Strength may be the production of collaborative approach of our neurons and muscle cells against the resistance. Muscular strength and power are generally acknowledged as being important in all team sports and sports that are dominated by speed (9).

Hand grip strength has been found to correlate with strength of other muscle groups and is thus a good indicator of overall strength. Consequently, grip strength measurements could be used for early screening of populations to identify those at higher risk of physical disability related to low muscle strength. In these persons, exercise interventions aimed at improving strength in all muscle groups could potentially lower the risk of subsequent physical disability. Muscle strength can be increased substantially by physical exercise at all ages (10).

The shoulder is a complex joint that affords the most degrees of freedom of any joint in the body. As such, there are several static and dynamic structures that act on the shoulder with every shoulder motion to maintain the humeral head in proper position. The overhead athlete, faces a multitude of forces about the shoulder with each athletic encounter (11). Evaluation of the glenohumeral joint of the unilaterally dominant upper extremity athlete with respect to internal and external rotation unilateral strength ratios and bilateral comparisons is an important part of a preventative conditioning program.

Stresses placed on the shoulder during the throwing motion, as well as the tennis serve and groundstrokes, require muscular support and control to prevent overuse injury. The importance of the posterior rotator cuff (supraspinatus (SSP), infraspinatus (ISP), and teres minor) in decelerating as well as stabilizing the humerus during the follow-through stage of the tennis serve and throwing motion (12).

Hence, the purpose of this study was to investigate the correlation between shoulder torque and hand grip strength in Egyptian tennis players.

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MATERIALS AND METHODS

Study design

Correlational one-shot study

Participants

Eighty-four players from both genders with age ranging from 17 to 25 years. Players were randomly assigned into one equal group. The study was conducted at the Faculty of Physical Therapy, Cairo University, Faculty of physical Therapy, (MUST- Misr University for Science and Technology) and different Egyptian clubs.

The inclusion criteria for participants were: 1-Tennis players between age group 17-25 from both genders. 2-Tennis players who do not have any previous injuries. 3-Players who are playing tennis at least from 1 to 2 years. 4- Tennis players with BMI ranging from 21 to 27 kg/m2

The exclusion criteria for participants were: Tennis players experiencing any past history of orthopedic or neurological involvement of upper extremity.

Measurement procedures

-Subjects were recruited from different clubs.

-Explanation of whole study for each participant.

-All players signed a consent form

-Demographic details of the subjects such as age, height and weight were collected, and BMI was calculated (13).

1. Hand grip Dynamometer:

The most common method of assessment for grip strength is the use of a hand grip dynamometer. Hand grip dynamometer is used to measure the muscular force generated by the flexor mechanism of the hand and the forearm (14).

It is a relatively inexpensive, simple, and clinically useful method to estimate total upper limb strength (12).

Due to its simplicity, low cost and technique reproducibility, the handgrip strength measurement is widely used to assess hand injuries (15).

Hand grip strength of the subject was assessed by Jamar hydraulic hand dynamometer (PC 5030JI, Preston Inc, USA) (14). Fig. (1)

Fig. (1): Hand grip strength dynamometer.

With the following position and procedure: -

•A calibrated hand grip dynamometer with adjustable grip was used.

•Initially the procedure was explained and demonstration was shown to the participants (13).

•The players were seated on a chair with back support and with their shoulder adducted and neutrally rotated, elbow flexed at 90, forearm and wrist in neutral position.

•The position of the hand remained constant without downward direction.

•The players were asked to put maximum force on the dynamometer three times by the dominant hand, and squeeze it forcefully and the value was recorded in kilograms (16).

•Three trials were taken with one-minute rest in between and the mean was calculated of these three trials and was taken as the mean grip strength which was calculated of the right hand (13).

2. Isokinetic dynamometer:

Isokinetic dynamometers Fig. (2) are computerized machines capable of providing multiple elements of measuring muscle strength, including peak force, endurance, power, angle of maximal force, and occurrence, and they are capable of generating strength curves. This form of testing has been used in the clinical setting for the purpose of measuring muscle strength for the past 35 years (17).

Isokinetic exercise machines or isokinetic dynamometers are mainly used to measure muscular strength in musculoskeletal rehabilitation which aims to restores optimal form of function after injury or surgery. The final stage of rehabilitation aims to return an individual to normal activities via resistance exercises that are usually focused at regaining muscle strength. Isokinetic exercise machine is considered as safe since an individual will never meet more resistance than he can handle because the resistance is equal to the force applied (18).

Isokinetic muscle testing is considered a reliable and valid instrument for muscle force testing and is often used as a reference standard to compare other instruments of measurement that test muscle strength. The more reliable the measurement, the higher the probability of adequate sensitivity to track small but clinically relevant changes (19).

Most isokinetic exercise machines are equipped with these components:

1.Computer System/Clinical Data System

2. Dynamometer

3. Attachments to parts of body, such as attachment for shoulder, elbow, wrist, ankle, knee, hip and/or upper body extremity table

Measuring of peak torque and work of the glenohumeral muscles were obtained on the Biodex System-3 Pro isokinetic dynamometer, (Biodex Medical Systems, Shirley, NY) (20). Fig. (2)

Fig. (2): Isokinetic device

Objective measurement of shoulder internal and external rotation strength is an important part in the comprehensive evaluation and rehabilitation of athletes who perform predominantly unilateral upper extremity movement patterns (21).

I. Instrument preparation:

Calibrations were performed immediately before the tests, following the manufacturer's recommendations and the axis of the dynamometer was aligned with that of the glenohumeral joint (20).

The testing apparatus was set up and participants positioned in the seated position and stabilized uniformly. The isokinetic dynamometer was calibrated using a certified weight before data collection (19). The dynamometer shaft was rotated at 30 degree and the participants were assessed in a seated position with their arms in the scapular plane (22) and the trunk was stabilized by two crossed straps.

Setup and positioning:

1. Seat player on chair.
2. Rotate chair to 15 degrees.
3. Rotate dynamometer to 20 degrees.
4. Attach Shoulder/Elbow attachment. Align shaft dot with right side and secure with locking knob.
5. Move player into position.
6. Raise dynamometer to align patient axis of rotation.
7. Stabilize player with shoulder, waist and thigh straps.
8. Set Range of motion (ROM) stops.

II.Subjects preparation:

Isokinetic assessment of internal and external rotation strength is also frequently performed in 900 of glenohumeral joint abduction. Specific advantages of this test position are greater stabilization in either a seated or supine test position on most dynamometers and placement of the shoulder in an abduction angle, corresponding to the overhead throwing position used in many sport activities (23).

The humerus was aligned with the rotational axis of the dynamometer.

The elbow was supported in 90◦

flexion, and the forearm and wrist were in neutral pronation/supination. Auto adhesive straps were placed horizontally across the chest and pelvis to stabilize the trunk to the seat (19).

During all tests, the participants received standardized verbal commands. All data were recorded and stored for future analysis (24).

•The participants were asked to execute three sub-maximal trials to familiarize themselves with the device and the test protocols.

•After a brief explanation of the testing procedures a rest is taken in between before the test.

•The tests consisted of three maximal Con.- Con. repetitions for the selected speed of 60_/s for the gleno-humeral movements.

•Players must be in comfortable position and stabilized by the belts to avoid substitution.

•Abdomen and chest areas are strapped with a belt to allow the muscle areas being measured can be subject to test exercises (25).

•Encouraging subjects by verbal commands to Position (2):

-Player reaching maximal internal rotation and starts to reach internal rotation with maximal power.

-Player seated in upright position stabilized with belts to avoid substitution

-Player was uniformly provided with standard commands to

Position (1):

reach maximal power. assume the starting test position, initiate testing, and end testing.

-Verbal commands were

-Player seated in comfortable position in the starting position towards external rotation with maximal power.

- Player seated in upright position stabilized with belts to avoid substitution

-Player was uniformly provided with standard commands to assume the starting test position, initiate testing, and end testing.

-Verbal commands were provided to the player to reach maximum power through out each repetition. provided to the player to reach maximum power through out each repetition.

Data analysis

The statistical analysis of the results was computed on the statistical package for social studies (SPSS) version 25 for windows. (IBM SPSS, Chicago, IL, USA) using:

1-Descriptive statistics of mean, standard deviation, frequencies and percentages were utilized in presenting the subjects demographic and measured variables. 2-Pearson correlation coefficient was conducted to investigate the correlation between hand grip strength and shoulder internal and external rotators' peak torque. 3-Simple linear regression was conducted to produce a formula to predict the values of shoulder internal and external rotators' peak torque from hand grip strength. 4-The level of significance for all statistical tests was set at $p < 0.05$.

RESULTS

Data collection: All subjects assessed one time as a (One shot study). Theywere assessed using the hand grip dynamometer to assess hand grip strength and isokinetic to assess shoulder torque.

- General characteristics of the subjects:

Eighty-four tennis players participated in this study. Their mean ± SD age, weight, height, and BMI were 20.75 ± 2.42 years, 67.92 ± 6.24 kg, 169.98 ± 5.36 cm and 23.47 ± 1.4 kg/m² respectively.

- Descriptive statistics of shoulderinternalandexternalrotators'peaktorque:

The mean ± SD shoulder internal rotators' peak torque of the study group was 20.84 ± 3.61 Nm with a minimum value of 13 Nm and maximum value of 27 Nm as shown in table 2.

The mean ± SD shoulder external rotators' peak torque of the study group was

11.62 ± 3.21 Nm with a minimum value of 5 Nm and maximum value of 17 Nm as shown in (table 3).

Table 2. Descriptive statistics of shoulder internal and external rotators' peak torque of the study group.

Peak torque (Nm)	$\bar{X}$ ±SD	Minimum	Maximum
Internal rotators	20.84 ± 3.61	13	27
External rotators	11.62 ± 3.21	5	17

$\bar{X}$: Mean SD: Standard deviation

- Descriptive statistics of hand grip strength:

The mean ± SD hand grip strength of the study group was 48.45 ± 4.23 kg with a minimum value of 40 kg and maximum value of 55 kg as shown in (table 3).

Table 3. Descriptive statistics of hand grip strength of the study group.

	$\bar{X}$ ±SD	Minimum	Maximum
Hand grip strength (kg)	48.45 ± 4.23	40	55

$\bar{X}$: Mean SD: Standard deviation

- Relationship between hand grip strength and shoulderinternalrotators'peak torque:

The correlations between hand grip strength and shoulder internal rotators' peak torque were strong positive significant correlations (r = 0.81, p = 0.0001). (Table 4).

Table 4. Correlation between hand grip strength and shoulder internal rotators' peak torque:

		r value	p value	Sig
Hand grip strength (kg)	**Shoulder internal rotators' peak torque (Nm)**	0.81	0.0001	**S**

r value: Pearson correlation coefficient p value: Probability value
S: Significant

- Relationship between hand grip strength and shoulderexternalrotators'peak

torque:

The correlations between hand grip strength and shoulder external rotators' peak torque were strong positive significant correlations (r = 0.89, p = 0.0001). (Table 5).

Table 5. Correlation between hand grip strength and shoulder external rotators' peak torque:

		r value	p value	Sig
Hand grip strength (kg)	**Shoulder external rotators' peak torque (Nm)**	0.89	0.0001	**S**

r value: Pearson correlation coefficient p value: Probability value
S: Significant

- Prediction of shoulder internal rotators'peaktorquefromhandgripstrength:

Hand grip strength can significantly predict the shoulder internal rotators' peak torque (F = 157.92, p = 0.0001). The prediction equation was

Shoulder internal rotators' peak torque = 0.691hand grip strength -12.659.

So that the shoulder internal rotators' peak torque increased by 0.691for each extra hand grip strength. The R^2 was 0.65 so 65% of the variation in shoulder internal rotators' peak torque can be explained by the model containing only hand grip strength. (Table 6).

Table 6. Regression coefficient of shoulder internal rotators' peak torque from hand grip strength:

R^2		**B**	**t- value**	**p value**	**Sig**	**95.0% CI**	
						Lower	**Upper**
0.65	**Constant**	-12.659	-4.73	0.0001	**S**	-17.98	-7.33
	Hand grip strength (kg)	0.691	12.56	0.0001	S	0.58	0.8

B: Regression coefficient p value: Probability value S: Significant CI: Confidence interval

- Prediction of shoulderexternalrotators'peaktorquefromhandgripstrength:

Hand grip strength can significantly predict the shoulder external rotators' peak torque (F = 343.51, p = 0.0001). The prediction equation was

Shoulder external rotators' peak torque = 0.681 hand grip strength -21.33. So that the shoulder external rotators' peak torque increased by 0.681 for each extra hand grip strength. The R^2 was 0.8 so 80% of the variation in shoulder external rotators' peak torque can be explained by the model containing only hand grip strength. (Table 7).

Table 7. Regression coefficient of shoulder external rotators' peak torque from hand grip strength:

R^2		B	t- value	p value	Sig	95.0% CI	
						Lower	Upper
0.8	Constant	-21.33	-11.94	0.0001	S	24.88	-17.77
	hand grip strength (kg)	0.681	18.53	0.0001	S	0.6	0.75

B: Regression coefficient p value: Probability value
S: Significant CI: Confidence interval

DISCUSSION

The present study was designed to investigate correlation between shoulder torque and hand grip strength in Egyptian tennis players. Isokinetic was used to measure shoulder torque and hand grip dynamometer was used to measure hand grip strength. Participants were stratified into one group.

The results of this study revealed that there was a significant correlation between shoulder torque and hand grip strength. The correlations between hand grip strength and shoulder internal rotators' peak torque were strong positive significant correlations (r = 0.81, p = 0.0001). The correlations between hand grip strength

and shoulder external rotators' peak torque were strong positive significant correlations (r = 0.89, p = 0.0001). The study revealed that the possible explanation of the significant correlation between the shoulder torque and hand grip strength that proximal

stability gives distal mobility. So, we have to focus on the proximal stability and muscles close to the center of the body to help in free movement of the distal body parts.

The findings of the present study were supported by Fawzy et al., (2020) as it has shown that There was a strong positive correlation between shoulder lateral rotator strength and HGS with the shoulder in 90° abduction and 90° abduction with 90° ER. These results could be attributed as the proximal stabilizers affect HGS, which depends not only on synergistic coordination between finger and wrist flexors and extensors, but also on proximal stabilization as many studies have emphasized the critical influence of elbow or shoulder position or movement on the strength of the hand muscles

The results of the present study were in agreement with Horsley et al., (2016) that have shown a positive correlation between hand gripping activity and rotator cuff muscle activity in line with the findings of the present study. The strong positive correlation found between the two variables in the present study is in agreement with the findings of Mandalidis and O'Brien, (2010) who investigated the relationship between isometric grip strength and isokinetic strength of the shoulder stabilizers.

Also, The findings of previous study by Mandalidis and O'Brien, (2010) revealed a statistically significant positive correlation between HG force and isokinetic average The relationship between HG strength and isokinetic moment of the shoulder stabilizers can partly be explained based on the mechanism by which an efficient action of the muscles that act at a distal joint can be performed only when the proximal joint or joints to it are also efficiently stabilized by the surrounding musculature.

Furthermore, the findings of the previous study by Nascimento et al., (2012) revealed statistically significant and positive relationships between isometric HG strength and isokinetic peak torque and work measures of the shoulder stabilizing muscles. Lee and Kim, (2016) stated that hand grip training is the prerequisite to activate supraspinatus muscle and infraspinatus muscle that affect stability of the shoulder. As a result of performing measurement of hand grip and manual muscle testing of the upper extremity, it shows high level of correlation to the hand, shoulder and elbow joint.

The results by Alizadehkhaiyat et al., (2011) showed that a forceful gripping task increases the activity of SSP and ISP

The results of the present study were in agreement with Au and Keir, (2007) were they stated that grip loads have been shown to increase both activity of the forearm and shoulder. Both intermittent and static hand gripping tasks were shown to increase supraspinatus and infraspinatus activity. While simultaneous hand exertions have been shown to elicit higher shoulder muscle activity in sub- maximal tasks.

Roberts et al., (2008) suggest that forearm and hand muscle afferents have strong divergent projections to more proximal joints via propriospinal pre-motoneurons and that these projections are modulated during functional activities. Greater sensitivity to afference from the hand may allow feedback to increase indirect corticospinal drive to infraspinatus.

Results of the conducted study together with those of other previous researchers & studies reviewed that there is a significant correlation between shoulder torque and hand grip strength.

CONCLUSION

On the basis of the study, we can conclude that there was a significant correlation between hand grip strength and shoulder torque in Egyptian tennis players. And this supports the importance of proximal stability for distal mobility.

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