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The correlation between university teaching staff's shoulder rotation torque and hand grip strength

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Abstract
Background: Teaching staff at universities often practice postures that can cause musculoskeletal problems, usually in the neck, shoulders, and lower back. Upper limb pain and musculoskeletal discomfort are very common.
Purpose: This study was conducted to show the correlation between shoulder torque of internal and external rotation and strength of hand grip and to determine the best position in measuring shoulder peak torque among university teaching staff.
Methods: Fifty-one university teaching staff members of both genders were chosen for this study from the Faculty of Physical Therapy at Misr University for Science and Technology. They worked an average of seven hours a day, were between the ages of 25 and 45, and had a BMI of 18 to 25 kg/m². Participants who performed overhead teaching activities for more than 2 hours daily for at least 1 year were assigned into one group. The Jamar Hydraulic Hand Dynamometer was used to assess grip strength, and isokinetic dynamometry was used to measure shoulder rotation torque.
Results: Right external rotator torque increased significantly at 90 degrees shoulder abduction as opposed to 45 degrees shoulder abduction ($p = 0.001$). When comparing 90 degrees shoulder abduction to 45 degrees shoulder abduction, there was a substantial increase in left external rotator torque ($p = 0.01$). On the right side there was no discernible difference in internal rotator torque between 45 degrees and 90 degrees abduction ($p = 0.07$). On the left side there was no discernible difference in internal rotator torque between 90 and 45 degrees abduction ($p = 0.65$).
Conclusion: After readings have been reached during assessment and rehabilitation, grip strength may be used to track the condition of the shoulder rotator. This study found a moderate correlation between grip strength and rotator torque at all positions for both hands.

Keywords: Hand Grip, Biodex Isokinetic, Academic Teaching Staff, Shoulder Rotator, Shoulder Rotation Torque, Hand Grip Dynamometer

Introduction

Teachers are more likely to suffer from work-related musculoskeletal diseases (WRMSDs) than in the past because they experience strain and discomfort in the upper extremities, neck, and back [1]. WRMSDs are more common among educators in Cairo, Egypt than among those in other areas [2]. Among all educational levels, university teaching staff report the highest rates, with a prevalence rate of up to 55% [3].

Since the shoulder is the human body's most mobile joint, it works by accurate coordination between its components to keep its function and stability. Shoulder stabilization is important for enabling efficient hand movements according to the proximal stability enabling distal mobility theory. Therefore the rotator cuff muscles as the infraspinatus (ISP) and subscapularis (SSP) are vital for keeping shoulder function during both high-demand and everyday activities [4]. Musculoskeletal problems can result from prolonged or severe pressure on these muscles whether from regular activities or demands at work [5].

Insufficient proximal stabilization can impair an individual's ability to generate maximal force, possibly reducing hand muscle strength. A significant link exists between hand grip strength (HGS) and lateral rotator strength across multiple hand positions on both the right and left sides. This suggests that hand grip strength evaluations may serve as a valuable tool for monitoring rotator cuff muscle strength and function [32]

Also, assessing grip strength is a helpful screening tool for identifying people who may be at risk of functional impairment due to its vital role in preserving muscular efficiency and preventing injuries [7]. The significance of evaluating both grip strength and shoulder biomechanics is supported by the literature since it indicates that proper scapular posture may improve upper limb function [8]

Among healthy individuals, a correlation was proven between HGS and the isokinetic strength of external shoulder rotators, abductors, and elbow flexors. This correlation suggests that isometric HSG may serve as a useful proxy for monitoring the isokinetic strength of muscle groups [33]

Nonetheless, there is no study in the literature on the connection between HGS and internal and external shoulder rotator torque, especially among college instructors. Therefore, this study aims to explore the association between shoulder rotation torque and HGS, while also identifying the optimal position for measuring peak shoulder torque among academic teaching staff.

Material and Methods

Study Design

The design of this study was cross-sectional. It was carried out at Misr University for Science and Technology's Faculty of Physical Therapy's Biodex Isokinetic Laboratory. The Faculty of Physical Therapy at Cairo University in Egypt's Research Ethics Committee granted ethical permission before to the study's start (No: P.T. REC/012/005456). The Helsinki Declaration's guidelines for research involving human participants were followed in this study. The study protocol was registered online with the identifying number NCT06851689 on ClinicalTrials.gov.

Sample Size Calculation

In the current study, the correlational bivariate model's sample size was calculated using an a priori power analysis. Every crucial parameter needed to determine the sample size was found. The relationship between shoulder external rotation and hand grip strength was the main finding. Based on the correlation found in a prior investigation [9], which was the most pertinent to the current study, the effect size (Correlational, p H1) of 0.29 was determined and entered into the G power program.

The study's power (1-β err prob) was set at 0.8, and the alpha error of probability (α) was set at 0.05. According to the software's sample size calculation, a minimum of 46 people should be included in the sample. According to the formula for sample size considering dropout (ND = N/ (1-d)), the total sample size should rise to 51 by accounting for 10% of sample dropout and ensuring a good power of significance [9].

Participants

Fifty-one participants of both genders were selected in this study from the teaching staff of the Faculty of Physical Therapy, Misr University for Science and Technology. Their ages ranged between 25 and 45 years [10] and their BMI within the range of 18.5–25(11). Participants were required to be engaging in overhead teaching activities or other teaching activities for at least one year [1] and They had to be working an average of seven hours per day. After explaining the scope and purpose of the research and informing them of their right to leave the study at any time and of the privacy of any information obtained, each participant signed an informed consent before starting the study. All data was coded to secure privacy.

The participants were excluded if they had a recent history of fractures, surgery or major injuries affecting the shoulder, upper limb, neck or thoracic region [10]. A history of neurological disorders affecting the upper limb [1], regional tumors, or metastasis of the upper limb also was one of the exclusion reasons [12]. Additional exclusion criteria included any trauma or injury within the last six months, known pregnancy [3], engagement in intense physical exercise or work outside university hours [3], and a history of surgery within the last six months, epilepsy, or chronic neurological conditions [13].

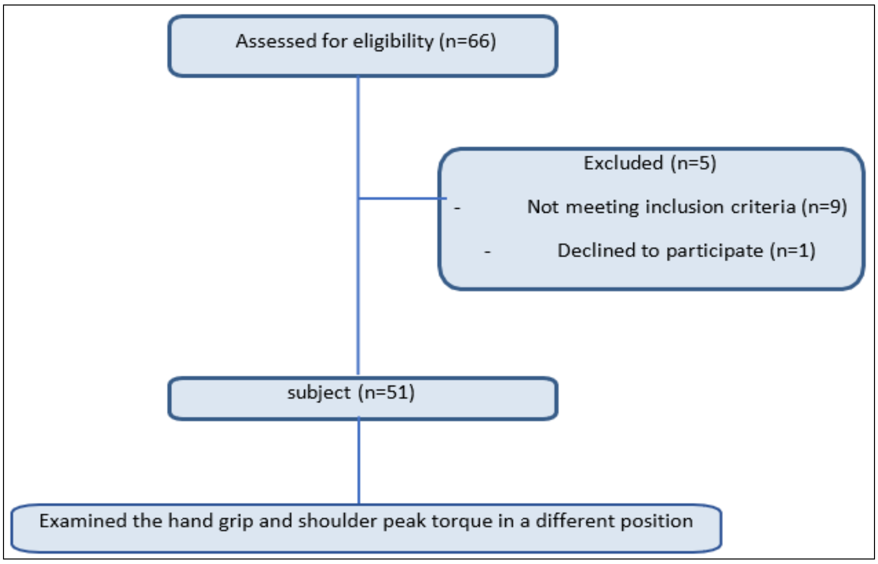

Fig 1: flow chart of study participants

Instrumentation

Hand Grip Dynamometer

Grip strength is commonly assessed using a hand dynamometer, the most reliable tool for evaluating grip and overall upper-body strength [10]. This study utilized the Jamar® Hydraulic Hand Dynamometer (Jamar, Product model J00105, U.S.A), a device known for its high reliability, minimal variability, and strong test-retest and interrater reliability (14). It has demonstrated intraclass correlation coefficients of 0.996 to 0.999, confirming its accuracy in both clinical and research settings [15]. Designed to accommodate different hand sizes, particularly female users, it measures grip strength up to 200 lbs. (90 kg) and features an adjustable handle with five grip spacings for optimal fit. Additionally, it allows for easy readability and recalibration to maintain measurement precision [16].

Biodex Isokinetic System

The isokinetic dynamometer is believed to be a reliable tool for assessing muscle performance due to consistent measurements that correlate with the symptoms patients report and functional assessments [17]. These machines consist of a computer or clinical data system, a dynamometer, and various attachments designed for different body parts including the shoulder, elbow, wrist, ankle, hip and upper limbs [4]. Due to their safety, accuracy, and reliability, isokinetic dynamometers serve as the benchmark for muscle strength assessment, integrating kinetic parameters such as joint angle variations to offer comprehensive evaluations crucial for clinical decision-making [18]. Additionally, these computerized devices analyze multiple muscle strength factors, including peak force generation, endurance levels, power outputs, and the precise angle of maximal force, while also generating strength curves for detailed assessment [4].

Weight and Height Scale

The participants' height and weight were measured using a standardized weight and height scale to determine their BMI and exclude those who were outside the usual range.

Procedure

Initially the participants had a comprehensive explanation of the study objectives and process by the researcher. In order to calculate BMI and other criteria to assess the participant's eligibility to be included in the study, demographic information and personal data, including age, height, and weight, were recorded. After a thorough description of the study methodology participants who fulfilled the inclusion criteria were asked to sign a consent form. Hand grip strength and shoulder rotation torque were the study's two primary outcome measures. To reduce the possibility of confounding variables that may impact the study's findings, all measurements were taken during a single session.

Hand Grip Strength Assessment

Hand grip strength (HGS) was assessed using the Jamar® Hydraulic Hand Dynamometer with all devices recalibrated at the beginning of the study to ensure accuracy [19]. The researcher provided detailed instructions and demonstrations before measurement guided by the study's protocol. All equipment was inspected for damage and proper functionality before use [14]. HGS was measured in two positions: in the first, participants maintained a neutral shoulder alignment with elbows flexed at 90 degrees while seated with back support. They squeezed the dynamometer with maximum force three times using their dominant hand, with each attempt recorded in kilograms [4]. In the second position, participants had their shoulders abducted to 90 degrees and again performed three maximal-effort squeezes, with one-minute rests between trials, and the mean value was calculated [4]. This protocol was applied to both hands in both positions, and participants were instructed to maintain their grip force until the needle stabilized for accurate readings [19].

Shoulder Rotators Assessment

The assessment of shoulder rotation was conducted using the Biodex Isokinetic System 4 at the Isokinetic Lab at Misr University for Science and Technology. The dynamometer was calibrated before each measurement, aligning its axis with the glenohumeral joint to assess IRTP/ERTP and peak torque of internal and external shoulder rotations bilaterally. Participants completed a 5-minute arm cycle ergometer warm-up before testing in two positions. In the first, they were seated with the shoulder abducted at 45° and elbow flexed at 90°, stabilized with straps to restrict trunk movement. A safety key defined the range of motion, and the forearm length was adjusted to maximize engagement [5]. For evaluation, the dynamometer was rotated 20° and tilted 50°, with participants positioned in the scapular plane, elbows at 90°, and forearms neutral. Gravitational correction was applied before performing maximal external and internal rotation in a concentric-concentric protocol at 60°/s for five repetitions [20].

In the second position, the shoulder was abducted at 90°, ensuring better stabilization while isolating rotator cuff muscle action. Elbows remained at 90° flexion, forearms neutral, and trunk secured with diagonal straps. Participants grasped the chair's handgrip with the opposite hand while performing five repetitions at 60°/s in one set [21]. The procedure involved seating the participant, rotating the chair 15°, rotating the dynamometer 20°, tilting it 5°, securing shoulder/elbow attachments, and aligning the dynamometer with the axis of rotation [4].

Statistical analysis

The obtained data and the demographics of the subjects were presented using descriptive statistics. The relationship between hand grip strength and the torque of the external and internal rotators was examined using the Pearson correlation coefficient. A paired t-test was conducted for comparison of hand grip strength between the neutral position and 90° shoulder abduction and between external and internal rotators torque at 90° and 45° shoulder abduction. The level of significance for statistical tests was set at $p < 0.05$. All statistical measures were performed through the statistical package for social sciences (SPSS) version 25 for windows.

Results

Subjects' characteristics

Fifty-one university teaching staff members included in this study. Their mean ± SD age and BMI were 28.49 ± 3.90 years and 23.24 ± 1.82 kg/m², respectively.

Table 1: Participant characteristics.

	Mean ± SD	Maximum	Minimum
Age (years)	28.49 ± 3.90	25	45
BMI (kg/m²)	23.24 ± 1.82	18	25
	N (%)		
Sex, N (%)			
Females	38 (75%)		
Males	13 (25%)		

SD, Standard deviation

Correlation between hand grip strength and external and internal rotators torque

The torque of the rotators of the right shoulder at both 90° and 45° abduction was moderately positively significant (r = 0.462 to 0.678, p < 0.001) correlated with the strength of the right-hand grip in the neutral position.

Both the torque of rotators of the left shoulder at 90° and 45° abduction showed a moderately positive significant association with the strength of the left-hand grip in the neutral position (r = 0.493–0.677, p < 0.001).

The torque of the rotators of the right shoulder at both 90° and 45° abduction was somewhat positively significant correlated with the right-hand grip strength in 90° shoulder abduction (r = 0.471 to 0.681, p < 0.001). The torque of the left shoulder's external and internal rotators at both 90° and 45° abduction was strongly to moderately positively significant correlated with the left-hand grip strength in 90° shoulder abduction (r = 0.507 to 0.743, p < 0.001). (Table 2).

Table 2: Correlation between hand grip strength and external and internal rotators torque:

Hand grip strength (kg)		Torque (Nm)	At 90° abduction		At 45° abduction	
			r value	p-value	r value	p-value
Neutral position	Right hand	Right External rotators	0.678	0.001	0.665	0.001
		Right Internal rotators	0.575	0.001	0.462	0.001
	Left hand	Left External rotators	0.677	0.001	0.645	0.001
		Left Internal rotators	0.493	0.001	0.564	0.001
90° shoulder abduction	Right hand	Right External rotators	0.681	0.001	0.679	0.001
		Right Internal rotators	0.579	0.001	0.471	0.001
	Left hand	Left External rotators	0.743	0.001	0.679	0.001
		Left Internal rotators	0.507	0.001	0.592	0.001

r value: Pearson correlation coefficient; p-value: Probability value.

Comparison of hand grip strength between the neutral position and 90° shoulder abduction.

Hand grip strength was significantly lower in the 90° shoulder abduction position compared to the neutral position for both the right and left hand ($p < 0.01$). (Table 3).

Table 3: Comparison of hand grip strength between the neutral position and 90° shoulder abduction.

Hand grip strength (kg)	Neutral position	90° shoulder abduction	MD	t- value	p-value
	Mean ± SD	Mean ± SD			
Right hand	28.68 ± 9.64	27.44 ± 10.26	1.24	2.95	0.005
Left hand	27.15 ± 9.72	25.94 ± 10.04	1.21	2.83	0.007

SD, Standard deviation; MD, mean difference; p-value: Probability value.

Comparison of external and internal rotators torque between 90° and 45° shoulder abduction.

External rotator torque was significantly higher at 90° shoulder abduction compared to 45° for both the right and left sides ($p < 0.01$); while there was no significant difference in right and left internal rotators torque between 90° and 45° shoulder abduction ($p > 0.05$). (Table 4).

Table 4: Comparison of external and internal rotators torque between 90° and 45° shoulder abduction.

Torque (Nm)	90° shoulder abduction	45° shoulder abduction	MD	t- value	p-value
	Mean ± SD	Mean ± SD			
External rotators					
Right	27.55 ± 9.31	23.71 ± 6.88	3.84	4.92	0.001
Left	26.14 ± 8.80	24.04 ± 7.49	2.1	2.59	0.01
Internal rotators					
Right	28.53 ± 12.54	26.28 ± 12.90	2.25	1.87	0.07
Left	23.77 ± 11.73	24.07 ± 12.50	-0.3	-0.46	0.65

SD, Standard deviation; MD, mean difference; p-value: Probability value.

Discussion

This study examined the relationship between academic teaching staff members' hand grip strength and shoulder torque, as well as the impact of various shoulder postures on these metrics. The findings showed that external rotator torque increased significantly for both sides at 90° shoulder abduction as opposed to 45° abduction ($p = 0.001$, $p = 0.01$). However, there was no significant difference in internal rotator torque between these positions on either side ($p = 0.07$, $p = 0.65$). Additionally, at 90° shoulder abduction, hand grip strength significantly decreased in comparison to the neutral position ($p = 0.005$, $p = 0.007$). A significant moderate positive correlation was found between hand grip strength in the neutral position and the torque of both internal and external rotators at 45° and 90° shoulder abduction.

The current study demonstrated that there is no statistical significance in internal rotation but significance in external rotation at different angles of shoulder abduction. This explanation agreed with the explanation given by (Chen *et al*., 2020) that there was no difference in significance in peak torques between angle below 90 arm abduction in concentric, this study was done on young health population in 60 degree and 90 and 120 he found the PT in 60,90 is not significant between them because factor affect the concentric is length tension relationship and the length of latissimus dorsi elongated after 120 and other muscle of internal rotation do torque between 45-90 and sub acromion space decrease after 120,this leads to decrease work of scapular muscles such as the upper trapezius, middle trapezius, lower trapezius and serratus anterior.

According to (Neuman, 2017), the study found that between about 35 and 70 degrees of abduction, the minimal AHD (the acromiohumeral distance) shifts between the acromion and the attachment site of the supraspinatus at the greater tubercle of the humerus, and this support the result of the significant between 45 and 90 abduction in external rotation to different in the space and when AHD decrease in space between acromion and supraspinatus this lead to decrease in torque of external rotation.

According to (Mandalidis *et al*., 2010), the results revealed that the external rotation at 90 elevations, more muscle worked in this position. To provide stability to the joint, shoulder elevation requires the action of the primary movers, including the anterior part of the deltoid, as well as the long head of the biceps brachii (a shoulder abductor and elbow flexor), and the rotator cuff muscles, such as the infraspinatus and teres minor. This also occurred in abduction 90, which is why external torque is much higher in 90 abduction.

The results of a study conducted by (Horsley *et al*., 2016), revealed that the hand grip strength in neutral is stronger than 90 shoulder abduction. Another study that was done by (Seo *et al*., 2020) [27] that compared hand grip in neutral, horizontal adduction and horizontal abduction and the results revealed that the neutral is higher than in abduction shoulder and this results agreed with the results of the current study.

The reduction in hand grip strength at 90° abduction is in line with the study done by Eryiğit (2018) [26] As they discovered that grip strength is greater in a neutral shoulder position than abduction. This decrease might be explained by the activation of the shoulder stabilizing muscles at 90° which could take effort away from producing the maximum grip force. It was also proposed by Antony & Keir (2010) [28] that grasping influences the patterns of muscular activation resulting in increased activity in the posterior deltoid, infraspinatus, and trapezius muscles. This could change the distribution of force and limit the power of grip at higher abduction angles.

(Mandalidis & O'Brien, 2010) revealed similar findings based on the neuronal circuits in the central nervous system (CNS) that cause the agonists and synergists muscle groups responsible for a particular job to co-activate. According to the study that done by Turabi *et al*. (2022) [29], they revealed that proximal stability improves distal mobility, which explains the observed relationship between shoulder rotator torque and hand grip strength. Furthermore, it was shown by Alizadehkhaiyat *et al*. (2011) [30] that when do grip but by forceful this lead to increased the activity of SSP and ISPIt was proposed that strong projections to more proximal joints are made by afferents from the forearm and hand muscles via propriospinal pre-motoneurons, and that these projections are regulated during functional activities. Feedback may be able to enhance the indirect corticospinal drive to the infraspinatus if the hand is more sensitive to afference (Roberts *et al*., 2008).

According to Sporrong *et al*. (1995) revealed that elevated electromyographic (EMG) activity in the supraspinatus during grasping tasks, most likely as a result of stress-related muscle tension, provide additional support for this connection.

The findings aligned with existing literature on the biomechanics of shoulder stability and grip function, emphasizing the importance of neuromuscular coordination in upper limb performance. Future studies should explore the implications of these findings in clinical and athletic settings to optimize rehabilitation and training programs.

Limitations of the study

The limitations were the number of subjects, and the population was teaching staff without focus on gender or dominant or non-dominant

Conclusion

For both left and right hands in every position, this study discovered a moderate relationship between grip strength and internal and external rotator torque. This implies that, following baseline measurements, grip strength could be utilised to monitor shoulder rotator health

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