

Review Paper: Activation of Shoulder Girdle Muscles during Gripping Task: a Systematic Review of Literature

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ABSTRACT

Purpose: Muscle activation of the proximal parts is necessary for distal activities. In fact, proximal muscles provide stabilized and controlled base for distal parts activities. The purpose of this systematic review was to determine whether hand grip task can alert the activation of shoulder girdle muscles.

Methods: A literature search was done in PubMed, Scopus, Elsevier, Ovid, CINAHL, Science Direct, ProQuest, Thompson, EMBASE and Medline databases for the period of 1970-2012. The keywords in this search were: hand grip, electromyography, and shoulder muscles.

Results: Using these keywords, 50 papers were found of which 17 papers met the inclusion criteria and were analyzed. Electromyography technique was used in most papers. The result of most studies showed that high static hand grip force increases the activity of some shoulder muscles, particularly the stabilizer muscles (rotator cuff).

Conclusion: The results indicated that hand grip tasks can alert the activation of shoulder girdle muscles.

1. Introduction

Muscle activity of proximal parts is necessary for activation of distal parts. In fact, the stable activity of distal parts needs controlling the proximal parts. Thus, the stability of shoulder girdle is required for activity of distal parts such as fingers, wrists and elbows. Due to different injuries, strength and flexibility are often considered as the main components of assessment and physical treatments of patients [1, 2]. Many researchers use different training methods to improve shoulder stability by increasing the activity of stable shoulder muscles. As the reduction of shoulder girdle muscle strength and imbalance of shoulder rotation mus-

cles is associated with impingement syndrome, in physiotherapy, strengthening of weak muscles of glenohumeral and scapulothoracic is focused. In addition, it has been shown that external factors such as the intensity of the applied load and shoulder position affect relative activity of shoulder muscles. The activity of hand muscles, especially grip is an important kinesiologic part of many work activities and sports that can be involved in upper extremities disorders. There is a relationship between using hand tools and many cumulative trauma disorders (CTDs) of upper extremities, especially those involving the hand and wrists. The use of hand tools can affect more proximal upper extremities including muscles of the forearm, elbow and shoulder. Therefore, the activity of shoulder muscle is affected by hand activity [3, 4].

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Severe static grip force, especially with arm elevation, make greater load on some shoulder muscles [5]. Shoulder stabilizer muscles (rotator cuff) with hand activity, are more affected than mover muscles. Stability of glenohumeral joint with supraspinatus and infraspinatus muscles is a prerequisite for hand grip activity. This relationship can have biomechanical and clinical implications. Activation of the shoulder girdle muscles in common shoulder disorders (such as impingement syndrome and rotator cuff tears) is due to subsequent pain and movement limitation is difficult in many cases. Considering the kinetic chain perspective that emphasizes the extremities segments are related kinematically, it is assumed that even in hand neutral position (requiring no direct participation of shoulder), there is increased activity of major shoulder stabilizers during severe hand activity resulted from co-activation of proximal and distal muscles. Hand grip also increases the activity of forearm muscles and biceps [6]. Understanding that how shoulder muscles are activated during hand activity, lead us towards supporting mechanisms, prevention strategies and more effective rehabilitation. If direct movements cause pain in the shoulder, shoulder rehabilitation is often postponed. Most patients with rotator cuff disorders are not able to do functional movements due to pain or pain avoidance [6]. Hence, if grip facilitates the activation of shoulder muscles without any pain in shoulder, it can be done in the early stages of shoulder rehabilitation. Therefore, the purpose of this re-

view study was to investigate the impact of hand activity on activity of shoulder girdle muscles.

2. Methods

To evaluate the effect of distal constriction on proximal parts, several databases in past 5 decades (1976-2012) were considered subjectively in English including CINAHL, Ovid, Elsevier, Scopus, Pub Med, EMBASE, Thompson, Pro Quest, Science Direct, and Medline databases. The keywords in this study were shoulder, tool, upper extremity, rotator cuff, muscle activity. The studies were selected that evaluated the effect of distal contraction of upper extremities on activity of shoulder girdle muscles, published in English, and were available.

3. Results

Using these keywords, 50 articles were obtained of which 17 articles met the inclusion criteria and were analyzed. Team members first read the headlines, and then selected relevant papers. The findings of these papers are summarized in Table 1. Most of the articles that did not meet the inclusion criteria were excluded for the following reasons: some of them were case study; a number of them were not available in full text or they were abstracts presented at a conference.

Table 1. Summary of reviewed articles

Author / Publishing Year	Sex and Number of Study Subjects	Purpose of the Study	Tools and Methods of Measurement	Conclusion
P. Herberts et al. (1976) (7)	10 male welders (50-65 years old)	Study of painful shoulder in old welders	Electromyography of glenohumeral and scapulothoracic muscles during welding in the elevated position of upper extremities	The results show that in welding in the overhead position, supraspinatus is constantly tired.
Schuldt et al. (1987) (8)	10 healthy right-handed professional female workers	Analysis of the effect of different sitting postures on activity level of some neck and shoulder muscles in a standard series of activity including shoulder - hand movements	Electromyography of glenohumeral and scapulothoracic muscles during writing in different elevated positions of upper extremities	There was a tendency to increase the activity during activity of arm and hand at higher levels compared to lower levels in muscles. Most activities were performed while the whole spine was bent.
H.Sporrong et al. (1996) (9)	9 healthy subjects (6 female and 3 male)	Effect of hand grip on shoulder muscle activity	Electromyography of glenohumeral and scapulothoracic muscles during static grip	Statistic hand grip task especially at high angles increases the force on shoulder muscles especially on the rotator cuff.
B.Laursen et al. (1998) (10)	6 healthy female	A model predicting individual's shoulder muscle strength based on the relationship between EMG and 3D external force in a static status	Electromyography of glenohumeral and scapulothoracic muscles during pushing or pulling in standard position of forearm	Most muscles altered their activity on the basis of the direction and type of activity.

Author / Publishing Year	Sex and Number of Study Subjects	Purpose of the Study	Tools and Methods of Measurement	Conclusion
H.Sporrong et al. (1998) (11)	10 healthy subjects (1 male and 9 female)	The effect of light manual labor on shoulder muscle - an electromyography analysis	Electromyography of glenohumeral and scapulothoracic muscles during hand grip in different flexion angles of upper extremities	An increase in muscle activity was observed in all muscles in all positions. (On average, 22% increase in activity compared to the rest position).
G.Palmerud et al. (2000) (12)	10 healthy male	intramuscular pressure of infraspinatus and supraspinatus muscles in relation to hand loading and arm position	Electromyography of glenohumeral and scapulothoracic muscles during hand loading in elevated position of upper extremities	Increasing elevation angle and hand loading initially increases intramuscular pressure of both muscles.
D.Roman-Liu et al. (2001) (13)	10 right-handed male	Assessment of musculoskeletal strength of trapezius and deltoid during hand activity	Electromyography of glenohumeral and scapulothoracic muscles during pushing a doorknob by hand in 45° arm abduction	Hand activity affects the lower part of the trapezius muscle, but has no influence on deltoid muscle. Accuracy of doing the work can affect the shoulder muscles and the load, even if only the hands are involved.
D.Roman-Liu et al. (2002) (14)	9 healthy right-handed male	Electromyography of activity of arm and forearm muscles during hand grip force with respect to the positions of upper extremities	Electromyography of glenohumeral, scapulothoracic and forearm muscles during hand grip in different angles of arm flexion	Different positions of upper extremities affect grip strength. This hypothesis that the position of upper extremities affects activity of muscles that are responsible for hand grip force is confirmed.
D.Mandalidis et al. (2008) (15)	18 healthy male	The relationship between isometric force of hand grip and isokinetic torque force of shoulder stabilization	Electromyography of glenohumeral, scapulothoracic and arm muscles during grip task in different angles of upper extremities elevation	There is positive relationship between hand isometric strength and arm isokinetic torque cuff, arm abductor and elbow flexors (regardless of the dominant hand). Also isometric hand grip strength can be used for monitoring isokinetic strength of specific muscles of shoulder stabilizer.
Brookham et al. (2009) (3)	10 healthy subjects (5 male and 5 female)	Impact of position, activity, and loading of hand on shoulder muscle activity	Electromyography of glenohumeral, scapulothoracic and arm muscles during hand loading in isometric and dynamic activity of shoulder in three pages	By increasing shoulder flexion, the activity of all muscles and especially lower trapezius muscle increases.
J.Domizio et al. (2009) (16)	12 healthy subjects (6 right-handed male and 6 right-handed female)	Impact of forearm position and hand grip on pushing and pulling	Electromyography of glenohumeral, scapulothoracic and forearm muscles during pushing and pulling with grip in standard status of arm and three status of forearm	Hand grip with pushing or pulling reduces the stress and injury on forearm muscles, but by adding grip to pushing and pulling, the alter of anterior and posterior deltoid muscles activity is not considerable
N. Antony et al. (2010) (5)	16 healthy subjects (8 male and 8 female)	Impact of position, activity, and loading of hand on shoulder muscle activity	Electromyography of glenohumeral and forearm muscles during pushing and pulling with grip in four elevated position of upper extremities	Hand grip alter shoulder muscle activity (middle and anterior deltoid show decrease in activity, and other muscles show an increase in activity). By increasing the shoulder activity, muscles activity is also increased.
O.Alizadehkhayat et al. (2011) (6)	16 healthy subjects (9 male and 7 female)	Activity and fatigue of the shoulder muscles in a controlled hand grip	Electromyography of scapulothoracic muscles during grip task in standard status of arm	The results showed that grip increases the activity of both muscles but no signs of fatigue in the muscles were reported.
MP.H. Smets et al. (2011) (17)	10 healthy right-handed female	Impact of kept grip force on muscular activity of upper extremities and strength of arm muscles	Electromyography of glenohumeral and forearm muscles during grip in two levels of arm elevation (in shoulder and elbow) and in 5 direction	Grip reduces the maximum strength of arm (18-25%) and muscular activity (15-30%) in all test positions.

Author / Publishing Year	Sex and Number of Study Subjects	Purpose of the Study	Tools and Methods of Measurement	Conclusion
S Lee et al. (2011) (18)	34 healthy male divided to two group (with and without grip)	Effect of contraction of finger Flexor muscle during activity of shoulder stabilizer muscles	Electromyography of glenohumeral and scapulothoracic muscles during abduction and adduction in two po with and without grip in 4 status of hand loading	As shown in both group (with grip and without grip), when the weight bearing by hand is increased, the activity of shoulder stabilizer muscle is also increased. Sports using finger flexors muscle are effective for patients who need Strengthening exercises because of weakness of stabilizer shoulder muscles.
P.J. Keir et al. (2012) (19)	10 healthy subjects (10 right-handed male and 10 right-handed female)	Impact of force, frequency and gripping on upper extremities muscle activity during periodical pushing	Electromyography of glenohumeral, arm and forearm muscles during frequent pushing by forearm was horizontal.	There is a complicated relationship between activity of upper extremities muscles and shoulder, and amount of force and frequency so that adding a grip may reduce the effects of transmission. Increasing loading and frequency of muscle activity significantly affect proximal muscles.
JN.Hodder et al. (2012) (20)	10 healthy male	Impact of a limited gripping on muscle activity and variability of shoulder muscles	Electromyography of glenohumeral, scapulothoracic and arm muscles during grip task in 90° arm elevation	Grip significantly reduces the activity of anterior deltoid, trapezius and latissimus dorsi muscles and increases the activity of other muscles.

PHYSICAL TREATMENTS

In Table 1, the results of the literature review regarding the number and type of samples, measurement tools, and upper extremities position are as following:

The number and type of samples: the number of studied subjects in all studies were >34; in 8 studies, there were 10 samples [17,20, 3,7,8,11,12,13]; in 2, 9 samples [9,14]; in 2, 16 samples [6,5]; in one, 6 samples (n = 10); in one, 18 samples (n = 15); in one, 12 samples [16]; in one, 20 samples [19] and in one study, there were 34 samples [18]. Of 17 studies, 7 studies selected male and female [19,3,5,6,9,11,16], 6 studies, only male [20,18,7,12,13,14,15], and 3 studies only female [8,10,17]. Of these 17 studies, only one study has been done on patients with shoulder pain [7] and the other studies have been done on healthy people. Of 15 studies in which electromyography was used to evaluate the muscular activity, 5 studies used surface electromyography and needle electromyography [7,9,10,11,14], 8 studies used surface electromyography [3,5,13,16,17,18,19,20], and 1 study used needle electromyography [6]. To assess muscle activity, a study used microcapillary infusion technique and three-dimensional motion analysis system [12], and another study used isokinetic devices [15]. In all studies, the shoulder girdle muscles were examined but in 7 studies in addition to shoulder girdle muscles, the forearm muscles have also been investigated [3,5,14,15,16,17,19].

In 9 of the 17 studies, the supraspinatus muscle was examined as one of the major muscles of the shoulder that in 8 studies [6,7,8,9,10,11,12,15] results have shown that among examined muscles, this muscle while working with hand or hand loading in all positions of shoulder has the highest activity. The results of only one study have shown that trapezius muscle is the most active one [5].

4. Discussion

In this study, 17 articles on activity of distal parts and its impact on the muscles of proximal part of the same side were reviewed that by classification of the results based on the following topics they will be discussed in detail.

4.1. Impact of gripping and hand loading on altering shoulder girdle muscles activity

In 9 of the 17 studies, the supraspinatus muscle was examined as one of the major muscles of the shoulder that in 8 studies [6,7,8,9,10,11,12,15], the results have shown that among examined muscles, this muscle while working with hand or on hand loading in all positions of shoulder has the highest activity. For example, the study of Alizadehkhayat (2011), P. Herbert (1976) and H. Sporrang (1996,1998) showed that grip task activates rotator cuff, especially the supraspinatus muscle that can be used for shoulder rehabilitation. It was reported that doing a light activity by hand in elevated positions of shoulder en-

hances the activity of trapezius and deltoid muscles about 20% more than the same position without light manual labor [6,7,9,11]. Holding 1 or 2 kg load during flexion or abduction enhances the activity of the deltoid, trapezius and supraspinatus muscles and to a large extent the activity of infraspinatus muscle (Sigholm et al., 1984) [21]. It was also shown that adding a griptask during shoulder contractions affect shoulder muscle activity while does not affect external torque shoulder (Sporrong et al., 1995, 1996; Mac Donell and Keir, 2005; Visser et al., 2006) [22,23,24]. About 30- 50% of hand grip force, increases the activity of supraspinatus and infraspinatus muscles by 10% of maximum voluntary exertion (MVE), while decreases the muscle activity of middle deltoid [9,11]. Under similar conditions, Au and Keir (2007) found that applying a grip force about 30%, whereas the abductor torque 40% is maintained for shoulder, decreases the muscle activity of middle and anterior deltoid about 2% MVE [25]. Therefore, it seems that gripping leads muscular activity from deltoid muscles towards the rotator cuff. It can explain why rotator cuff muscles are the most common injured parts in shoulder in occupational injuries [26].

Roman-liu (2001) showed that hand activity affect descending part of the trapezius but does not affect deltoid muscle and also the accuracy of the work can affect the arm and shoulder muscles [13]. Antony reported that gripping reduces the activity of middle and anterior deltoid muscle and increases the activity of other muscles [5]. Also, Keir (2012) showed that grip increases the activity of all muscles but triceps. In fact, grip will affect more proximal muscles [19].

In contrast to the above studies, MPH Smets (2011) found that grip reduces the maximum arm strength (18-25%) and muscle activity (15-30%) in all test positions. It seems that if the effect of grip on shoulder muscle activity is due to mental effort created by a visual feedback to control the grip force, muscle activity would be reduced due to habit or learning. Based on this research, grip reduces the activity of many muscles in shoulder, especially activity of the anterior deltoid, trapezius and latissimus dorsi [17]. Also, JN. Hodder (2012) showed that adding grip to kept posture of shoulder alters activity of tested muscles. The most considerable result is that grip significantly reduces the activity of the anterior deltoid, trapezius and latissimus dorsi and enhances the activity of other muscles [20]. J. Domizio (2009) also evaluated the hand activity with grip, pushing and pulling with and

without hand grip and found that hand grip with pushing or pulling reduces the stress and injury on forearm muscles, but by adding grip to pushing and pulling, the alteration of anterior and posterior deltoid muscles activity is not considerable [16]. S. Lee also found that by increasing the hold load on the hand, the muscle activity of studied muscles in both groups (with grip task and without grip task) is increased. This result shows that proximal parts activity is essential for distal parts activity [18].

4. 2. The impact of position on activity of upper extremities muscles

When arm is raised, external torque of shoulder is maximized to 90° angle and muscle activity is also increased to support external torque. It was shown that shoulder muscle activity is increased in both flexion and abduction positions even if external torque in laboratory conditions be kept in a relative fix rate (P.Herbert 1976., Sigholm et al., 1984; Mac Donell and Keir, 2005). When the angle of shoulder is enhanced over 90°, reduction of muscle length and moment arm reduces muscles torque; therefore, although shoulder external torque even without additional load is reduced, more muscle activity is required [7,21,23]. Palmerud et al. (2000) found that intramuscular pressure of infraspinatus and supraspinatus muscles with increasing flexion and abduction angles are increased over than 40mmhg that a pressure more than this can significantly disturb the muscular blood flow and subsequently lead to muscular injury [27]. S. chuldt (1987) also reported that during writing by pen, there was a significant decrease in muscular activity level while Thoracic – Lumbar spine were slightly declined towards back [8]. Roman-liu (2002) also showed that in 4 different positions of upper extremities, the maximum force of hand is different. In addition, this suggestion is confirmed that the position of upper extremities affect muscular activity of muscles producing hand grip force. This phenomenon also is seen in extensor carpi radialis and anterior deltoid muscles. The activity of flexor carpi ulnaris and biceps muscles is significantly related to magnitude of hand force and is not sensitive to the position of upper extremities [14].

Most of the studies showed that static hand grip force specially with increasing the angle of arm elevation increases the activity of some shoulder muscles. Stabilizer muscles (rotator cuff) are more affected than mover muscles by hand activity. Only the study of H. Sporrong showed that by increasing the elevation angle of arm, no

significant alteration is seen in shoulder muscle activity compared to lower angles [11].

5. Conclusion

Regarding the examined studies, it was found that in most of studies grip activate the whole upper extremities and even proximal parts especially rotator cuff (especially supraspinatus). In conclusion, distal contraction can activate the muscles of proximal parts that probably require stabilization by proximal muscles to activate distal parts.

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