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Electromyographic activity of the external rotator and trapezius musculature during two rehabilitative exercises

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Abstract

A preliminary study to analyze EMG activity of shoulder muscles of masonry workers during two rehabilitative exercises is done in the present work. Masonry workers do lot of overhead activities, and are exposed to a high risk of shoulder injury. Shoulder injury is mainly due to an imbalance between internal rotator muscles accelerating the arm and the external rotator muscles responsible for the deceleration of the arm at the end of movement. This imbalance commonly occurs in overhead activities during work. Two rehabilitative exercises considered in the present study are (1) Prone ER at 90º abduction with elbow at 90º while upper arm is resting on the table and (2) Standing ER at 0º abduction with 90º elbow flexion. Results indicate that middle trapezius has the highest level of activation in 'Prone ER at 90º abduction with elbow at 90º while upper arm is resting on the table' (exercise 1). Middle trapezius and lower trapezius presented significantly higher activations in exercise 1. But, posterior deltoid presented significantly higher iEMG activity in exercise 2.

Keywords: Masonry workers, Trapezius, Rotator cuff, Posterior deltoid, EMG

Introduction

The dynamic stabilization of the rotator cuff muscles plays an important role in maintaining the functional stability of the shoulder (Apreleva, et al. 1998; Bradley, 1991). The balance between external and internal rotation strength is important to normal glenohumeral joint function, especially during overhead occupational activities (Wilk, 1997). The risk of shoulder injury depends on the style of the work performing task, time-periods of work and the level of associated muscle fatigue (Illyes, 2005). The aim of this study is to analyze the EMG activity of different shoulder muscles of masonry workers during two shoulder rehabilitative exercises (SRE). Shoulder rehabilitative exercises, in general, have potential for alleviating shoulder pain.

Materials and methods

Eight male masonry workers participated in this study (Table-1). Each subject is informed about the objective, procedures and risks involved in the study before performing experimentations.

Two SRE are performed in the Lab: (1) Prone ER at 90º abduction with elbow at 90º while upper arm is resting on the table

(Figure-1) and (2) Standing ER at 0º abduction with 90º elbow flexion (Figure-2). These SRE are done with a dumbbell of weight 3.0 kg. It is ensured that workers are not over exhausted during exercises. They are provided appropriate rest periods.

Table 1: Demographic data.

No. of participants	Age ± SD (year)	Weight ± SD (kg)	Height ± SD (m)	BMI ± SD (kg/m^2)
8	35.38 ± 10.97	57.75 ± 9.30	1.67 ± 0.03	20.49 ± 2.70

We use Acknowledge 4.1 software, Biopac MP150 (BIOPAC Systems, Inc., Santa Barbara, CA) to process EMG signals. Measurement of EMG signal is done using Biopac System with the Ag-AgCl bipolar electrodes. EMG signals are measured for external rotator muscles, which include three muscles namely posterior deltoid (PD), infraspinatus (IS) and teres minor (TM), and for trapezious musculature, which also comprises three muscles, namely upper trapezius (UT), middle trapezius (MT), and lower trapezius (LT). Middle five EMG signals are considered out of total seven repetitions while excluding first and last signal for the purpose of accuracy of measurement.

EMG procedures are followed as per the available standards (International Society of Electrophysiology and Kinesiology, 1999). Skin preparation is done using standard procedure before placing electrodes. Skin is shaved using razor and spirit at designated areas. EMG signals are processed in the following manner for each of six muscles mentioned above. Raw EMG signals are firstly band-pass filtered. Then they are full-wave rectified and then finally low-pass filtered with a Butterworth second order and a frequency cut-off. Matlab software (Matlab 7.10, R2010a, 23, 2010) is used for implementing above-mentioned processing of EMG signals. The normalization of EMG data of each muscle type is done by the maximum EMG value of that muscle during all exercises.

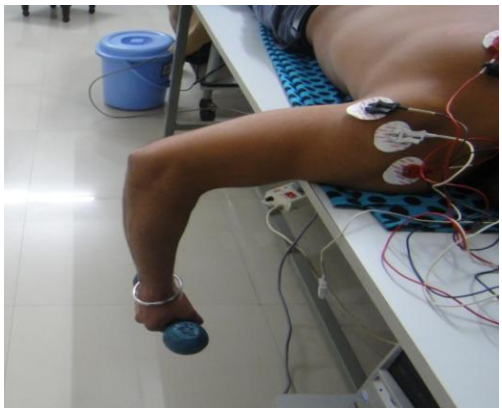

Figure 1: Prone ER at 90º abduction with elbow at 90º while upper arm is resting on the table.

Figure 2: Standing ER at 0º abduction with 90º elbow flexion.

Average integrated EMG (iEMG) differences among the exercises are tested for statistical significance using a separate one-way repeated measures analysis of variance (ANOVA) for each muscle. A probability (P) of 0.05 is set as the criterion for statistical significance. Four muscle synergies are defined (Marta, et al. 2013). External rotator synergy (ER_{syn}) is the mean of iEMG values from IS, TM and PD muscles. Rotator cuff synergy (RC_{syn}) is the

mean of iEMG values from IS and TM. Trapezius synergy (T_{syn}) is the mean of the iEMG values from UT, MT and LT. Total shoulder synergy (TS_{syn}) is the mean value of ER_{syn} and T_{syn}. This analysis has not been done only for each muscle but also for ER_{syn}, RC_{syn}, T_{syn} and TS_{syn}. Means and standard deviations are calculated for all these parameters.

Results

For each exercise, Table-2 shows percentage MVC of iEMG (% MVC ± SD) for UT, MT and LT. Between two exercises, MT activity is the highest (82.66% MVC). Statistical analysis shows that it is significantly higher in exercise 1 than exercise 2. Also MT activity is higher than both, UT as well as LT, in exercise 1. Further, LT activity is significantly higher in exercise 1 than in exercises 2. But UT iEMG activity is not significantly different for exercises 1 and 2.

Table 2: Mean (±SD) EMG activation of the Upper Trapezius (UT), Middle Trapezius (MT) and Lower trapezius (LT) in the total movements expressed in %MVC for masonry workers.

Exercises	UT	MT	LT
Ex-1	55.59 ± 22.74	82.66 ± 10.63	55.39 ± 22.44
Ex-2	51.19 ± 21.20	32.00 ± 10.16	27.04 ± 5.37

The highest iEMG activity in PD is observed in exercise 2 (53.01% MVC) in Table-3. iEMG activity of PD is significantly higher in exercise 2 than exercise 1. Statistical analysis shows that IS iEMG activity is not significantly different in exercises 1 and 2. It is also statistically inferred that TM activity is not significantly different for exercises 1 and 2.

Table-4 demonstrates statistical results of the different synergies in each exercise, whereas T_{syn} is significantly highest (64.55 %MVC) in exercise 1. RC_{syn} is not significantly different. ER_{syn} is not significantly different for exercises 1 and 2. It is statistically inferred that TS_{syn} is significantly higher in exercise 1 than exercise 2.

Table-5 illustrates results of ratios UT/MT and UT/LT, for each exercise. Table 5 reveals that UT activity is superior to MT and LT activities in exercise 2. However, it is inferior to MT in exercise 1.

Table 3: Mean (± SD) EMG activation of the Posterior Deltoid (PD), Infraspinatus (IS) and Teres minor (TM) in the total movements expressed in %MVC for masonry workers.

Exercises	PD	IS	TM
Ex-1	27.53 ± 7.74	41.07 ± 24.64	48.53 ± 24.11
Ex-2	53.01 ± 29.85	27.68 ± 14.51	47.28 ± 25.89

Table 4: Mean (± SD) value of normalized average (% of the EMG of the MVC) of Trapezius Synergy (T_{syn}), Rotator cuff synergy (RC_{syn}), the external rotator synergy (ER_{syn}), and Total Shoulder synergy (TS_{syn}).

Exercises	T_{syn} ((UT+ MT +LT)/3)	RC_{syn} ((IS+ TM)/2)	ER_{syn} ((PD+ IS+ TM)/3)	TS_{syn} ((ER_{syn} + T_{syn})/2)
Ex-1	64.55 ± 13.43	44.80 ± 16.16	39.04 ± 8.85	51.79 ± 9.59
Ex-2	36.94 ± 8.21	37.48 ± 15.15	42.66 ± 13.71	39.80 ± 9.66

Table 5: Ratio of the mean value of normalized (% MVC) of the UT/MT, and UT/LT ratio in the total movements.

Exercises	UT/MT	UT/LT
Ex-1	0.69	1.06
Ex-2	1.78	1.98

Discussion and conclusion

Results of the present study can be used to decide the proper rehabilitative exercise for masonry workers suffering with shoulder pain. For all six muscles, statistically significant differences were calculated using iEMG activity for each exercise. MT has the highest iEMG activation in Prone ER at 90º abduction with elbow at 90º while upper arm is resting on the table (exercise 1). Further, LT activity is significantly higher in exercise 1. For PD highest iEMG activation is observed in Standing ER at 0º abduction with 90º elbow flexion (exercise 2). But number of research studies show that horizontal abduction exercises produce high iEMG activations for posterior deltoid muscle (Hintermeister et al. 1998; Reinold et al. 2004). For IS and TM, there is no significant differences in iEMG activations for both exercises. RC_{syn}, T_{syn} as well as TS_{syn} have higher values in exercises 1 which is clear but ER_{syn} is higher in exercise 2. However, T_{syn} and TS_{syn} are significantly different iEMG activation in exercise 1 than exercise 2. As per the results of trapezius intramuscular ratio it may be concluded that exercises 2 contribute to abnormal scapular motion (Cools et al. 2004; Cools et al. 2007). It is intended that in future more subjects would be taken up to ensure higher accuracy of the results. Also future studies should include more number of rehabilitative exercises to decide the better ones for each of six shoulder muscles under considerations.

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Conflict of interest: None

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