

Original Article

Electromyography activity of the deltoid muscle of the weight-bearing side during shoulder flexion in various weight-bearing positions

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Abstract. [Purpose] This study investigated the deltoid muscle activation during shoulder flexion exercise in various weight-bearing positions. [Subjects] A total of 15 males participated. [Methods] The participants completed three repetitions of shoulder flexion exercises in three positions (prone-on-elbow, quadruped, and standing) with electromyography activity being collected from the exercised. The muscle activations in each position by each exercise were compared using a one-way analysis of variance. [Results] The electromyography activities of the middle and posterior deltoids differed significantly among positions. The prone-on-elbow and quadruped position showed a significantly higher activity than the standing position. There were no significant differences between the prone-on-elbow and quadruped positions. [Conclusion] The deltoid muscles were further strengthened in the low posture positions (prone-on-elbows and quadruped) than in standing.

Key words: Electromyography, Deltoid, Weight bearing

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INTRODUCTION

The use of weight-bearing exercises during shoulder rehabilitation has gained popularity¹⁾. Such exercises, sometimes termed closed kinetic chain (CKC) exercises, performed with the hand in contact with a stable surface, have been suggested to promote proprioception, joint stability, and muscle co-activation around the shoulder²⁾. The incorporation of weight-bearing exercises has been suggested at various phases of rehabilitation programs. Examples of CKC exercises for the upper extremity are push-ups, pull-ups, the wall press, quadruped, and tripod. Uhl et al.³⁾ suggested that the prayer and quadruped positions were appropriate for early rehabilitation because of the low activity levels of all muscles, and the tripod and pointer positions placed intermediate demands on the infraspinatus and deltoid muscles. The deltoid muscle has been classically divided into three anatomical portions—the anterior, middle, and posterior—and activation pattern during shoulder motion differs among the three portions⁴⁾. The force lines of the middle deltoid and supraspinatus are similar during shoulder abduction. During abduction, the two muscles can help stabilize the humerus head in a functional concavity formed by the inferior joint

capsule⁵⁾. The posterior deltoid is important for maintaining the dynamic stability of the shoulder joint⁶⁾. Strengthening of the posterior deltoid is desirable for ensuring shoulder joint integrity, enhancing athletic performance, and reducing injury potential⁷⁾. The purpose of this investigation was to measure the electromyography (EMG) activity of the deltoid muscle during general shoulder flexion exercises in various weight-bearing positions.

SUBJECTS AND METHODS

This study subjects were 15 healthy males (age, 28.40 ± 2.13 years; height, 172.70 ± 6.17 cm; weight, 70.59 ± 7.24 kg) with no history of pathological problems or conditions including musculoskeletal and neurological disorders. This study purpose and methods were explained to the subjects before their participation, and they provided informed consent according to the principles of the Declaration of Helsinki. The EMG activities were recorded using a surface MP150 (Biopac Systems, Santa Barbara, CA, USA). The posterior deltoid electrode was centered approximately two fingerbreadths behind the angle of the acromion. The middle deltoid electrode was placed along the line from the acromion to the lateral epicondyle of the elbow corresponding to the greatest bulge of the muscle. EMG data were normalized to the maximum voluntary isometric contraction (MVIC). The MVIC is the standard manual muscle test position used to normalize the middle and posterior deltoid.

All subjects performed the shoulder flexion exercises on the three positions of prone-on-elbow, quadruped, and standing in a randomized order. In shoulder flexion, subjects

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lifted the arm on one side with the shoulder joint in 180° flexion. At this time, with the back of the hand facing up, the therapist put a hand on the back of the subject's hand to provide appropriate resistance at the end of the range. Data from each exercise were recorded for 5 s. All subjects performed each exercise three times with a 30-s rest between trials and a 1-min rest between exercises to reduce fatigue. Resistance was provided by the same physical therapist throughout the study period. A one-way analysis of variance was conducted to identify significant differences among the task performances. A post hoc least significant difference analysis with a significance level of $\alpha = 0.05$ was performed to evaluate differences among tasks.

RESULTS

The middle deltoid in the prone-on-elbow and quadruped positions ($38.07 \pm 25.01\%$ and $31.27 \pm 8.45\%$, respectively) had a significantly higher %MVIC than the standing position ($15.12 \pm 12.01\%$) ($p < 0.05$). The middle deltoid in the prone-on-elbow and quadruped positions ($31.55 \pm 19.80\%$ and $37.05 \pm 11.52\%$, respectively) had a significantly higher %MVIC than that in the standing position ($5.84 \pm 4.69\%$) ($p < 0.05$). However, there was no significant difference between the prone-on-elbow and quadruped positions in the middle and posterior deltoid ($p > 0.05$).

DISCUSSION

The middle and posterior deltoid muscles were significantly more active in the prone-on-elbows and quadruped positions than in the standing position. Ackland and Pandy⁶ suggested that the deltoid muscle afforded significantly superior shear capacity at the glenohumeral joint and that the deltoid muscle contributed to glenohumeral joint stability. Uhl et al.³ suggested that one-handed weight-bearing exercises (the tripod position) focused on posterior deltoid and infraspinatus muscle activities. The deltoid controls or prevents excessive dropping of the contralateral shoulder and maintains the frontal aspect of the trunk parallel to the floor. The initial exercises were performed below the shoulder level and included weight-bearing on a table while standing.

The weight-bearing exercises progressed from the table to the quadruped position⁸). Our study obtained similar results in the present study: the activities of the deltoid muscle increased to maintain the trunk parallel to the floor during the shoulder flexion exercise in the prone-on-elbow and quadruped positions. High-level muscle activity was evident in the prone-on-elbow and quadruped positions, featuring more weight-bearing than the standing position. However, the muscle activity difference was not significant between the prone-on-elbow and quadruped positions. The deltoid muscle activity was significantly different between the quadruped and tripod position but not between the tripod and pointer positions³). The raised position of the CKC exercise is more effective in physical therapy for functional recovery of the infraspinatus muscle than the deltoid muscle⁹). Therapists generally think that it is possible to grant a selective increase muscle activity and greater muscle resistance around the shoulder through a postural change. This study showed no significant difference between the middle and posterior deltoid in the prone-on-elbows and quadruped positions.

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