



Original Article

Changes in the electromyographic activities of the infraspinatus and posterior deltoid according to abduction angles of the shoulder joint during shoulder external rotation in closed kinetic chain exercise

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Abstract. [Purpose] This study's purpose was to identify abduction angles of the shoulder joint that can provide effective infraspinatus muscle exercises while minimizing the muscle activity of the posterior deltoid muscle. [Subjects and Methods] The subjects of this study were 15 healthy young students in their 20s. Subjects adopted a standing position and performed shoulder external abduction while pushing their hands against the wall. The current research was undertaken to compare the activity of the infraspinatus muscle and the posterior deltoid muscle at abduction angles of 45, 90 and 135° of the shoulder joint during closed kinetic chain exercises. [Results] A activity of the infraspinatus muscle showed no statistically significant differences. The activities of posterior deltoid muscle were greater at the angle of 45° than at 90 and 135°. [Conclusion] These results indicate that to strengthen the infraspinatus, shoulder external rotation exercises at abduction angles of the shoulder joint greater than 45° are more effective.

Key words: Infraspinatus, Deltoid, Shoulder joint

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INTRODUCTION

To regaining motion of the shoulder after injury, it is necessary to activate the infraspinatus muscle while minimizing the activity of the posterior deltoid muscle during shoulder external rotation, in order to secure the stability of the shoulder joint^{1, 2)}. Kang et al. maintained that closed kinetic chain exercises are more effective than open kinetic chain exercises at activating the infraspinatus muscle while minimizing the activity of the posterior deltoid muscle³⁾. Jang and Oh claimed that when the shoulder is bent at 45 degrees, the activity of the posterior deltoid muscle is reduced⁴⁾. Ha et al. argued that the side-lying wiper exercise activates the infraspinatus muscle most effectively⁵⁾, while Kim et al. maintained that during shoulder external rotation while sitting, the infraspinatus muscle is activated while the activity of the posterior deltoid muscle is minimized⁶⁾. Jung et al. conducted research on the activity of the infraspinatus muscle during passive shoulder and active elbow exercises⁷⁾. While there have been studies on the effectiveness of exercises designed to strengthen the infraspinatus muscle, little research has been carried out on the shoulder abduction angles suitable for strengthening this muscle and minimizing the use of the posterior deltoid muscle⁸⁾. Therefore, the purpose of this study was to compare the activity of the infraspinatus and the posterior deltoid muscles at different abduction angles of the shoulder joint during closed kinetic chain exercises. In addition, it aimed to identify abduction angles of the shoulder joint that can provide effective infraspinatus muscle exercises while minimizing the activity of the posterior deltoid muscle.

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SUBJECTS AND METHODS

The subjects of this study were 15 healthy young students in their 20s attending Youngdong University in Chungbuk, South Korea. Subjects were included if they had no musculoskeletal or neurological disorders affecting the upper or lower extremities, lesions, or history of surgery on the spine or upper extremities. The subjects were selected randomly from among those who met the above criteria. The mean age, height, and weight of the subjects were 21.3 ± 1.6 years, 173.0 ± 4.3 cm, and 64.1 ± 6.1 kg, respectively. Ethical approval for the study was granted by the Institutional Review Board of Youngdong University. All subjects were fully informed of the objectives and methods of the study beforehand and gave their informed consent to participation in the experiments.

A MP150 surface EMG system (BIOPAC System Inc. Santa Barbara, CA, USA) was used to measure the activity of the infraspinatus muscle and the posterior deltoid muscle. Electrodes were placed 4 cm below and parallel to the spine of the scapula on the lateral aspect over the infrascapular fossa, and 2 cm below the lateral border of the spine of the scapula parallel to the muscle fibers on the dominant side to record the muscle activity of the infraspinatus and posterior deltoid of the dominant side, respectively⁹. To normalize the muscle activity of the infraspinatus and posterior deltoid muscles, the maximum voluntary isometric contraction (MVIC) technique was performed as recommended by Kendall et al¹⁰. Raw data were converted into the root mean square (RMS) and then expressed as %MVIC.

Subjects adopted a standing position and performed shoulder external abduction while pushing their hands against a wall. A pressure bio-feedback unit (Chattanooga Group, Hixson, TN, USA) was placed between the subjects' hands and the wall pressure was maintained by the subjects at 40 mmHg after an initial pressure setting of 20 mmHg. The subjects performed shoulder external rotation at 45, 90, and 135°, as instructed by a researcher, and were told to apply maximum pressure for 5 seconds during external rotation while maintaining the pressure of the pressure bio-feedback unit and the external rotation angles of the shoulder joint. Measurements were taken three times at each angle. The subjects were allowed to rest for 5 minutes between trials.

SPSS 12.0 was used for the statistical analysis, with a significance level of 0.05. To identify the differences in electromyographic activities at different angles, the Friedman test was carried out. The Wilcoxon Signed-Rank test was performed for post hoc analysis.

RESULTS

Activity of the infraspinatus muscle was measured as $8.3 \pm 4.0\%$ at of shoulder 45° was abduction angle, $7.7 \pm 4.8\%$ at the 90° abduction, and $9.6 \pm 6.7\%$ at 135° abduction, indicating the greatest muscle activity was at 135° of shoulder abduction, and there were no statistically significant differences among these values ($p > 0.05$). Activity of the posterior deltoid muscle was measured as $17.5 \pm 6.1\%$ at of shoulder 45° abduction, $13.7 \pm 3.4\%$ at 90° abduction, and $12.1 \pm 5.6\%$ at the 135° angle, showing the greatest muscle activity was at 45° of shoulder abduction, and there were statistically significant differences among the results ($p < 0.05$). A post-hoc examination indicated that the posterior deltoid was more activated at 45° abduction of the shoulder joint than at 90° or 135° ($p < 0.05$, $45^\circ > 90^\circ, 135^\circ$).

DISCUSSION

This study referred to research by Kang et al.³ and used a pressure bio-feedback unit during closed kinetic chain exercises because muscle activity was expected to differ during closed kinetic exercises performed at weight-bearing levels. In the present study, activity of the infraspinatus muscle showed no statistically significant differences ($p > 0.05$). However, Reinold, et al. maintained that the infraspinatus is highly activated when the abduction angle of the shoulder joint is at its minimum². In the present study 45° was the minimum abduction angle of the shoulder joint, while 0° was the minimum angle in the studies conducted by Reinold et al. It may be necessary to check the electromyographic activities of the infraspinatus muscle and the posterior deltoid muscle at abduction angles of the shoulder joint less than 45°, which was the smallest angle used in the research. Significant differences were observed in the electromyographic activities of the posterior deltoid muscle at different angles. In particular, the electromyographic activities of this muscle were greater at the shoulder abduction angle of 45° than at 90° and 135°. This result indicates that, shoulder external rotation exercises at abduction angles of the shoulder joint greater than 45° are more effective at strengthening the infraspinatus. The present study had the following limitations. First, all subjects were healthy males in their 20s; therefore, it would be difficult to generalize the findings to patients with shoulder pain or functional disorders who are female or who belong to other age groups. Second, as the experiment was conducted in a designated position and angle, changes in electromyographic activities in other positions were not measured. Therefore, it is suggested that future studies conduct experiments involving diverse illnesses and various positions as well as females and patients of various ages.

REFERENCES

- 1) Bitter NL, Clisby EF, Jones MA, et al.: Relative contributions of infraspinatus and deltoid during external rotation in healthy shoulders. *J Shoulder Elbow Surg*, 2007, 16: 563–568. [[Medline](#)] [[CrossRef](#)]
- 2) Reinold MM, Wilk KE, Fleisig GS, et al.: Electromyographic analysis of the rotator cuff and deltoid musculature during common shoulder external rotation exercises. *J Orthop Sports Phys Ther*, 2004, 34: 385–394. [[Medline](#)] [[CrossRef](#)]
- 3) Kang MH, Oh JS, Jang JH: Differences in muscle activities of the infraspinatus and posterior deltoid during shoulder external rotation in open kinetic chain and closed kinetic chain exercises. *J Phys Ther Sci*, 2014, 26: 895–897. [[Medline](#)] [[CrossRef](#)]
- 4) Jang JH, Oh JS: Changes in shoulder external rotator muscle activity during shoulder external rotation in various arm positions in the sagittal plane. *J Phys Ther Sci*, 2014, 26: 135–137. [[Medline](#)] [[CrossRef](#)]
- 5) Ha SM, Kwon OY, Cynn HS, et al.: Selective activation of the infraspinatus muscle. *J Athl Train*, 2013, 48: 346–352. [[Medline](#)] [[CrossRef](#)]
- 6) Kim JW, Yoon JY, Kang MH, et al.: Selective activation of the infraspinatus during various shoulder external rotation Exercises. *J Phys Ther Sci*, 2012, 24: 581–584. [[CrossRef](#)]
- 7) Jung MC, Kim SJ, Rhee JJ, et al.: Electromyographic activities of the subscapularis, supraspinatus and infraspinatus muscles during passive shoulder and active elbow exercises. *Knee Surg Sports Traumatol Arthrosc*, 2016, 24: 2238–2243. [[Medline](#)] [[CrossRef](#)]
- 8) Jang JH: The effects of infraspinatus muscle activity on humeral external rotation exercise in open and closed kinetic chain. Doctor's Degree, Daegu University, 2013.
- 9) Criswell E: *Introduction to Surface Electromyography*, 2nd ed. Sudbury: Jones and Bartlett Publishers, 2010.
- 10) Kendall FP, McCreary EK, Provance PG, et al.: *Muscles: Testing and function with posture and pain*, 5th ed. Baltimore: Williams & Wilkins, 2005.