



Original Article

Effect of axial shoulder external rotation exercise in side-lying using visual feedback on shoulder external rotators

DONG HYUN KIM, PT, MS¹⁾, TAE HO KIM, PT, PhD^{1)*}

¹⁾ Department of Physical Therapy, College of Rehabilitation Sciences, Daegu University:
201 Daegudae-ro, Gyeongsan-si, Gyeongsangbuk-do 38453, Republic of Korea

Abstract. [Purpose] This study aimed to determine effectiveness of axial side-lying wiper exercise using the visual feedback with a laser pointer on infraspinatus and posterior deltoid muscles. [Subjects and Methods] The subjects were 22 healthy adults (18 males, 4 females) in their 20s who consented to participate in the present study. Surface Electromyography was used to measure the infraspinatus and posterior deltoid muscle activity before and after an intervention. The intervention consisted of performing side-lying wiper exercise with a 1-kg dumbbell and a ruled paper for 30 minutes. [Results] The infraspinatus illustrated significantly increased muscle activity after intervention. The posterior deltoid also showed increased activity after intervention but it was not significant. [Conclusion] Axial side-lying wiper exercise using the visual feedback has the therapeutic effectiveness for the selective infraspinatus muscle strengthening. Therefore it can be useful to provide shoulder movements with stability.

Key words: Shoulder external rotation, Infraspinatus, Visual feedback

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INTRODUCTION

During shoulder movements, the rotator cuff (RC) provides stability for glenohumeral joint and functions as an approximation force to resist dislocation or subluxation of humerus^{1,2)}. When the RC is injured, the range of shoulder motion is limited and prone to instability during movements.

In this aspect, many researchers insisted on strengthening for the RC muscles selectively and investigated the methods to do it^{1,3-5)}. The infraspinatus muscle is particularly important during shoulder external rotation motion, functioning as a stabilizer and a prime mover. The approximation force of the infraspinatus muscle provides a resistance force to prevent distraction during overhead throwing movement¹⁾. The posterior deltoid muscle, which is not one of the RC muscles, is also activated during shoulder external rotation. Hyperactivation of the posterior deltoid muscle frequently results in anterior translation of the humeral head, leading to decreased shoulder stability⁴⁾.

Many previous studies have reported exercise methods aimed at selectively strengthening the RC muscles. The aim of such studies was to increase the activity of the infraspinatus muscle and decrease the activity of posterior deltoid muscle^{4,6)}. The studies reported that the ratio of the infraspinatus to posterior deltoid activity was significantly increased after selective exercise. To identify the most effective exercise to strengthen the infraspinatus muscle, Ha et al.¹⁾ compared four different exercise, including a side-lying wiper exercise (SWE), which was developed by the researchers. Among the four exercises, the SWE showed the greatest activity of the infraspinatus muscle and the relatively lesser activity of posterior deltoid muscle. As yet, there have been no studies aimed at determining the effectiveness of the SWE using a visual feedback instrument. Therefore the aim of the present study was to investigate the effectiveness of axial SWE using visual feedback.

*Corresponding author. Tae Ho Kim (E-mail: ptkimth@daegu.ac.kr)

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SUBJECTS AND METHODS

A total of twenty two healthy subjects (18 males, 4 females) with no shoulder conditions were recruited from a university population of Daegu University. Exclusion criteria were the presence or history of shoulder pain, musculoskeletal conditions, or neurological conditions that could interfere with shoulder external rotation in the test and intervention position. Subjects were provided a written informed consent according to the ethical standards of the Declaration of Helsinki, and all of them agreed to participate in current study voluntarily. The average age of the subjects was 23.5 ± 1.4 years, height was 172.0 ± 5.7 cm, weight was 73.0 ± 5.7 kg. The dominant arm was determined by asking the subjects to eat and write¹⁾ and all the subjects were right-arm dominant.

A surface electromyography system (EMG: TeleMyo DTS, Noraxon Inc., Scottsdale, AZ, USA) was used to measure muscle activities of the infraspinatus and posterior deltoid muscle. The points of the EMG electrodes were determined in accordance with previous studies^{1, 7)}. Disposable Ag/AgCl surface electrodes were attached 2 cm apart to each muscle. Electrodes for the infraspinatus muscle were placed 4 cm below the spine of the scapula on the lateral aspect over its infrascapular fossa. For the posterior deltoid muscle, electrodes were placed at lateral border of the spine of the scapula and angled on an oblique angle toward the extremity running parallel to the muscle fiber.

Before the pretest, the maximal voluntary isometric contraction (MVIC) was measured for the tested muscles to normalize EMG activity. Each subject was asked to perform a 5-second MVIC 3 times for each muscle against the manual resistance from the examiner. This study collected the EMG data for the middle 3 seconds. The infraspinatus muscle activity was measured while the subjects performed shoulder external rotation in an effort to stabilize the humeral head in the glenoid cavity⁸⁾. To measure the posterior deltoid muscle activity, the subjects performed shoulder horizontal abduction with a slight external rotation⁸⁾. The MVIC value used the average RMS of three trials. The average EMG activity was expressed as a percentage of the MVIC value (%MVIC). Before placing EMG electrodes, all sites for the attaching point were shaved with razors and deterged with an alcohol-soaked paper towel. The sampling rate was 1,000 Hz and EMG signals were filtered at 40–400 Hz by finite impulse response bandpass and 60 Hz filters and infinite impulse response rejector and the rectification.

As an intervention, subjects performed SWE for 30 minutes. They lay on the flat floor facing the wall, and flexed and rotated internally the right shoulder to 90° with elbow 90° flexion, and supported the distal part of humerus with the palm of the opposite hand. A laser pointer was placed on their humerus using an elastic Velcro strip to provide visual feedback. A paper with concentric circles which have 2, 5, 9 cm radius respectively was located at a distance of 1 meter from the subjects facing them. A 1-kg dumbbell was provided for the exercise and the subjects performed SWE, trying to minimize moving range of a beam shot from the laser pointer on the paper. When their wrist joint reached to a fixed set point, they maintained the posture for 5 seconds and returned to the starting position. They repeated it on the dominant side, its one period was 10 seconds, and after 1 minute repetition they took a rest for 30 seconds (Fig. 1).

For the pretest and posttest, subjects performed SWE with a 1-kg dumbbell on side-lying position, without the laser pointer and the paper with concentric circles, until their wrist joint reached to the fixed set point. Then, they maintained the posture for 5 seconds. This study collected the EMG data for the middle 3 seconds. They performed 3 trials with a 1-minute rest between trials to minimize the chance of muscle fatigue⁹⁾.

General characteristics were analyzed using descriptive statistics and results are reported as means and standard deviations. Wilcoxon Signed Rank test was used to analyze the changes of muscle activities of the infraspinatus and posterior deltoid between before and after intervention. The number of subjects was 22 and it was not enough to be analyzed by parametric statistics, so present study analyzed statistical data with non-parametric statistics. Statistical analyses were performed using SPSS (statistical package for the social sciences) version 18.0 for Window software (SPSS, Chicago, IL, USA). A value of $p < 0.05$ was considered to indicate statistical significance.

RESULTS

The infraspinatus illustrated significantly increased muscle activity after intervention ($p < 0.05$) (Table 1). The posterior deltoid also showed increased activity after intervention but it was not significant ($p > 0.05$) (Table 1).

DISCUSSION

This study investigated the effectiveness of using a laser pointer as a visual feedback tool in axial SWE for selective infraspinatus muscle strengthening. After the intervention, the infraspinatus muscle activity increased significantly compared to that of the posterior deltoid muscle. Ha et al.¹⁾ previously reported positive effects of the SWE in a selective strengthening exercise program for the infraspinatus muscle. Kang et al.²⁾ reported that the infraspinatus muscle activity increased significantly but that posterior deltoid muscle activity did not after subjects performed an intervention involving shoulder external rotation in a standing position with the shoulder at 90° flexion. Lim et al.¹⁰⁾ investigated the activities of two muscles with and without visual feedback using EMG signal input to the computer monitor, and reported that the ratio of the infraspinatus to posterior deltoid activity was greater with visual feedback than without it. Weon et al.¹¹⁾ reported that visual feedback using

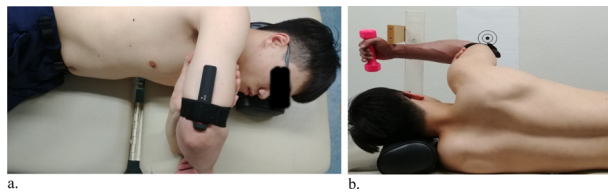


Fig. 1. Side-lying wiper exercise using laser pointer

The laser pointer was placed on a subject's humerus using an elastic Velcro strip to provide visual feedback (a). Subjects maintained that posture for 5 seconds when their wrist joint reached to a fixed set point (b)

Table 1. Electromyographic activities of the infraspinatus and posterior deltoid at pretest and posttest (N=22)

	% Maximal Voluntary Isometric Contraction (Mean ± SD)		
	Pretest	Posttest	Diff
Infraspinatus	21.9 ± 6.8	42.8 ± 14.4	20.8 ± 10.3
Posterior deltoid	6.8 ± 4.8	8.5 ± 6.1	1.6 ± 5.1

Diff: difference value; *p<0.05

video camera input to the computer monitor could be used to activate the upper trapezius and serratus anterior muscle to improve scapular movement. The present study used a laser pointer to develop the ability of axial rotation during intervention. According to Sahrman¹²⁾, an articular motion leads a path of instantaneous center of rotation (PICR), and the minimized PICR provides the motion with stability and normalcy. The minimized PICR of glenohumeral joint during shoulder external rotation is acquired when the infraspinatus muscle which is a local posture muscle functioning as a stabilizer and a prime mover contracts enough before the posterior deltoid muscle which is a global dynamic muscle causing large torque in the movement contracts. Subjects of this study repeated axial rotation in SWE and, it is considered that, the axial rotation could reduce the distance of PICR increasing the infraspinatus muscle activity which functions as a stabilizer and a prime mover during shoulder external rotation.

The current study has some limitations. First, all the subjects were healthy adults without pain. The results of the present study need to be compared with findings of studies involving patients with pain. Second, the number of subjects was small, making it difficult to generalize the results. Further studies are needed with larger numbers of subjects. In addition, long-term follow-up assessment is needed to investigate the long-term benefits of SWE together with visual feedback.

In conclusion, SWE using visual feedback with a laser pointer showed therapeutic effectiveness in selective infraspinatus muscle strengthening. Therefore, the SWE using visual feedback can help to enhance shoulder movement stability.

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