Effects of diagonal shoulder training in a closed kinematic chain for secondary impingement syndrome: a case study

Soo-Han Kim, PhD, PT1), Du-Jin Park, PhD, PT1)*

1) Department of Physical Therapy, College of Health Medicine, Kaya University: 208 Sanggye-ro, Gimhae, Kyongnam 609-757, Republic of Korea

Abstract. [Purpose] This study examined the effects of diagonal shoulder training on an individual with secondary impingement due to scapular dyskinesis. [Subject] A 54 year-old female with secondary impingement participated in this study. [Methods] The patient performed diagonal shoulder training in 4-point kneeling, 3 times per day for 20 minutes over a period of 6 weeks. Evaluations of shoulder pain, range of motion, upper trapezius/lower serratus anterior ratio, and impingement were performed before training and at 2, 4, and 6 weeks. [Results] The patient’s parameters improved gradually. All parameters returned to normal ranges at 4 weeks. [Conclusion] Diagonal shoulder training is effective for improving dysfunction in individuals with secondary impingement. In addition, this training should be applied for more than 4 weeks.

Key words: Diagonal shoulder training, Closed kinematic chain, Secondary impingement syndrome

INTRODUCTION

Shoulder impingement is a common musculoskeletal problem. Its primary cause is internal degeneration of the rotator cuff muscles; this can be caused externally by a deformity of the acromion and coracoacromial ligament1). Meanwhile, secondary impingement is caused by problems in muscle dynamics or incomplete combination of the scapula and glenohumeral joint. This is specifically caused by injuries of the joint capsule and ligament or muscle weakness and scapular dyskinesis2).

The trapezius and serratus anterior (SA) are the most important muscles in scapular kinesis; they are coupled, resulting in upward rotation of the scapula during the elevation of the arm above the head3). These muscles contribute to the movement and stabilization of the scapula when performing overhead work4). However, some people with shoulder problems exhibit scapular dyskinesis in which SA activity is diminished and upper trapezius (UT) activity is excessive during arm elevation5). The scapular dysfunction that can cause secondary impingement is due to excessive activity of the UT to compensate for the lack of SA activity. The ratio of the activation of the upper trapezius to the lower serratus anterior (UT/LSA) has been used to represent effects of shoulder training6, 7).

A recent study demonstrates diagonal shoulder training is more effective for improving the UT/LSA activity ratio than push-up plus exercise7). However, the effects of diagonal shoulder training on people with shoulder problems in clinical practice remain unknown, because the previous study7) only examined normal subjects. Therefore, this case study examined the effects of diagonal shoulder training on an individual with secondary impingement due to scapular dyskinesis.

SUBJECT AND METHODS

This is a case study of a 54-year-old woman with shoulder impingement syndrome who was referred to the Department of Physical Therapy, Busan ST. Mary’s Hospital because of pain and limitation of range of motion (ROM) in her right shoulder joint. On the basis of radiography and Hawkins-Kennedy test, she was diagnosed with secondary impingement syndrome without injury of the rotator cuff or shoulder ligament by an orthopedic specialist. In particular, the Hawkins-Kennedy test, which evaluates supraspinatus tendinitis or secondary impingement syndrome8), showed abnormalities related to supraspinatus tendinitis, which can cause secondary impingement. Her scapular dyskinesis, which can cause secondary impingement, was examined.

Scapular dyskinesis was examined as follows. The patient performed arm abduction to 90° for 3 seconds. The UT/LSA activity ratio, pain, and ROM were evaluated during the overhead work task. Shoulder pain and ROM were measured using a visual analogue scale and goniometer (Plastic goniometer, Baseline Inc., USA). Surface electromyography (MP150, BIOPAC Systems Inc., USA) was used to determine muscles activities. The signals were amplified...
and band-pass filtered (20–450 Hz) before being digitally recorded at 1,000 Hz. Two surface electrodes were placed on the affected side (right): on the UT at approximately half the distance between the 7th cervical spinal process and acromion and LSA on the belly of the muscle branching to the 7th rib. 7)

Electromyography amplitudes were normalized according to the reference voluntary isometric contraction (RVIC). RVIC was measured at 90° shoulder abduction in scapular plane elevation, which is used to evaluate individuals with impingement. On the basis of her shoulder condition, she wore a 5-lb sandbag on the right forearm; previous studies used a 15-lb sandbag. 6, 7) Finally, RVIC was measured at 90° of scapular plane elevation for 3 seconds. This study conformed to the ethical principles of the Declaration of Helsinki, and the patient provided written informed consent for the treatment and use of the case data for scientific purposes and publication.

The patient performed diagonal shoulder training in 4-point kneeling with her hands and knees placed vertically below her shoulder and hip joints, respectively. She then lowered her right ischial tuberosity diagonally towards the opposite heel (left heel) while fixing her arms on the floor. While she moved her trunk diagonally backward, she applied a proprioceptive neuromuscular facilitation (PNF) pattern by pressing the right arm toward the floor in flexion, abduction, and external rotation directions. She performed diagonal shoulder training in 4-point kneeling for 20 minutes 3 times per week for 6 weeks. Evaluations were performed repeated 2 times before training and after 2, 4, and 6 weeks.

**RESULTS**

Pain, ROM, the UT/LSA activity ratio, and shoulder impingement improved gradually during training (Table 1).

**DISCUSSION**

Shoulder pain and ROM improved dramatically at 6 weeks. Shoulder pain decreased approximately 86%, ROM increased approximately 50%. These improvements are likely because of the application of an upper-extremity PNF pattern in a closed kinematic chain, which can be controlled by shoulder motion itself without pain. In shoulder rehabilitation, closed kinematic chain may effectively diminish the weight of the arm and decrease the demand on the weakened rotator cuff. 10) In addition, the patient’s improved impingement and ROM corroborate the findings of previous studies in that PNF training provides traction to the shoulder.

The normal UT/LSA activity ratio is less than 1 during shoulder abduction beyond 90°. 9) Although she had an abnormal UT/LSA activity ratio of 1.31, this returned to the normal range at 4 weeks, indicating recovery of scapular kinesia. Therefore, the results indicate diagonal shoulder training is effective for improving shoulder pain, ROM, scapular dyskinesis, and impingement in individuals with secondary impingement due to scapular dyskinesia. In addition, this training should be applied for more than 4 weeks to individuals with secondary impingement. Future research is required to confirm the effects of PNF training for various shoulder problems.

**REFERENCES**

1) Cleeman E, Flatow EL: classification and diagnosis of impingement and rotator cuff lesions in athletes. Sports Med Arthrosc Rev, 2000, 8: 141–157. [Medline] [CrossRef]
2) Magee DJ: Orteopedic Physical Assessment, 5th ed. Elsevier, 2010, pp 245–382.[Medline] [CrossRef]
3) Ebaugh DD, McClure PW, Karduna AR: Three-dimensional scapulothoracic motion during active and passive arm elevation. Clin Biomech (Bristol, Avon), 2005, 20: 700–709. [Medline] [CrossRef]
4) Ludewig PM, Reynolds JF: The association of scapular kinematics and glenohumeral joint pathologies. J Orthop Sports Phys Ther, 2009, 39: 90–104. [Medline] [CrossRef]
5) Ludewig PM, Cook TM: Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. Phys Ther, 2000, 80: 276–291. [Medline]
6) Park SY, Yoo WG: Differential activation of parts of the serratus anterior muscle during push-up variations on stable and unstable bases of support. J Electromyogr Kinesiol, 2011, 21: 861–867. [Medline] [CrossRef]
7) Park DJ, Lee HO: The intramuscular activation of scapular stabilizing muscles during push-up plus and PNF exercises in a quadruped position. J Phys Ther Sci, 2013, 25: 371–374. [CrossRef]
8) Khan KM, Cook JL, Taunton JE, et al.: Overuse tendinosis, not tendinitis part 1: a new paradigm for a difficult clinical problem. Phys Sportsmed, 2000, 28: 38–48. [Medline] [CrossRef]
9) Neumann D: Kinesiology of the Musculoskeletal system, 2nd ed. Elsevier, 2010, pp 126–178.
10) McMullen J, Uhl TL: A kinetic chain approach for shoulder rehabilitation. J Athl Train, 2000, 35: 329–337. [Medline]

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**Table 1.** Changes in shoulder pain (VAS), ROM, the UT/LSA activity ratio, and impingement (Hawkins-Kennedy test) during training

|                      | Baseline | 2 weeks | 4 weeks | 6 weeks |
|----------------------|----------|---------|---------|---------|
| VAS                  | 7        | 5       | 2       | 1       |
| ROM                  | 112      | 130     | 157     | 168     |
| UT/LSA activity ratio| 1.31     | 1.18    | 0.92    | 0.81    |
| Hawkins–Kennedy test | (+)      | (+)     | (−)     | (−)     |

Values are means; VAS: visual analogue scale; ROM: range of motion; UT/LSA: upper trapezius/lower serratus anterior