



Original Article

Effect of altered carrying angle on the medial-to-lateral activation ratio in the biceps brachii and triceps brachii

GA-HEE KIM¹⁾, A-YOUNG LEE¹⁾, SO-YOUNG PARK¹⁾, YUN-JUNG HEO, BHc, PT¹⁾,
BO-RAM CHOI, PhD, PT¹⁾*

¹⁾ Department of Physical Therapy, College of Health and Welfare, Silla University:
315 Euisaengmyung-gwan, 700 Bakyangdae-ro, Sasang-gu, Busan 46958, Republic of Korea

Abstract. [Purpose] The purpose of this research was to examine differences in muscle activity between the resting forearm position (RFP) and the straight forearm position (SFP) during upper arm strengthening exercises. [Participants and Methods] In total, 35 healthy college students were randomly sampled (18 males and 17 females). Surface electromyography data were collected from the medial and lateral sides of the biceps and triceps brachii muscles. [Results] The medial muscles showed greater activity during SFP versus RFP, but no difference in overall activation was found between the two positions. [Conclusion] Carrying angle less affected to biceps and triceps brachii muscles activation during upper arm strengthening exercises.

Key words: Carrying angle, Cubitus valgus, Upper arm strengthening exercise

(This article was submitted Feb. 27, 2018, and was accepted May 7, 2018)

INTRODUCTION

An appropriate carrying angle (CA) prevents contact between the upper and lower extremities when pulling an object. In addition, an optimal CA can aid in correctly positioning the hand (i.e., at the center of gravity of the object), thus promoting stability of the lever arm^{1, 2)}. However, a large CA can cause instability and pain in the elbow during physical exercise or other activity³⁾. Thus, attention should be paid to the CA during arm movements to avoid negative outcomes when exercising.

The attachment points of the biceps brachii muscles are located at the short head (medial side) and long head (lateral side). The triceps brachii muscles also have a long head (medial side) and lateral head (lateral side)⁴⁾. Because the upper arm and forearm are not in a perfectly straight line, the medial and lateral sides of the biceps and triceps brachii muscles may be activated asymmetrically during upper arm strengthening exercises. We hypothesized that the straight forearm position (SFP) would produce more symmetrical activation of the medial and lateral muscles than resting forearm position (RFP). In this study, we examined the differences in activity between the medial and lateral biceps brachii and triceps muscles, in both the SFP and RFP, during upper arm strengthening exercises.

PARTICIPANTS AND METHODS

In total, 35 healthy participants were randomly sampled (males, n=18; mean age, 22.1 ± 1.61 years; mean height, 174.1 ± 6.5 cm; mean weight, 74.7 ± 10.1 kg; females, n=17; mean age, 21.9 ± 0.8 years; mean height, 161 ± 3.3 cm; mean weight, 58.0 ± 3.8 kg). The inclusion criteria were no current trauma or pain in the upper extremities; and normal range of motion of the shoulders, elbow joints, and forearms. The study received ethics approval from the Human Research Ethics Committee of Silla University (1041449-201605-HR-004). Muscle activation was measured using surface electromyography (4D-SES;

*Corresponding author. Bo-ram Choi (E-mail: boram@silla.ac.kr)

©2018 The Society of Physical Therapy Science. Published by IPEC Inc.



This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (by-nc-nd) License. (CC-BY-NC-ND 4.0: <https://creativecommons.org/licenses/by-nc-nd/4.0/>)

Relive Corp., Korea). The electrodes were attached to the short and long heads of the biceps brachii muscles, and to the long and lateral heads of the triceps brachii muscles. Reference electrode was attached to the lateral epicondyle. A sampling rate of 1,000 Hz and a frequency range of 20–450 Hz were employed. The electromyography data were converted into maximal voluntary isometric contraction values. The medial-to-lateral activation ratio was given by medial muscle activation divided by lateral muscle activation. In the RFP, the participant extended the elbow joint by a comfortable resting position on him and herself. In the SFP, the upper arm and forearm were arranged in a straight line along sagittal plane by assistant. The biceps brachii and triceps brachii exercises were performed in an upright and a prone position, respectively^{5, 6)}. The dumbbell weight was set at 7 kg for men and 3 kg for women. The starting position of the exercises required 90° flexion of the elbow joint, with the wrist maintained in a neutral position. Each exercise was performed using the dominant arm. The exercise was repeated five times with 1 min rest between exercises. The data were analyzed using SPSS for Windows software (ver. 18.0; SPSS Inc., Chicago, IL, USA). The paired-samples t-test was used to compare differences in the medial-to-lateral activation ratio between the two exercise positions. The significance level for all analyses was set at $p < 0.05$.

RESULTS

The medial muscles showed greater activation than the lateral muscles, in all four position (male participants: biceps brachii, RFP= 1.13 ± 0.29 , SFP= 1.22 ± 0.30 ; triceps brachii, RFP= 1.01 ± 0.49 , SFP= 1.09 ± 0.56 ; female participants: biceps brachii, RFP= 1.15 ± 0.24 , SFP= 1.25 ± 0.30 ; triceps brachii, RFP= 1.05 ± 0.28 , SFP= 1.09 ± 0.24). However, no difference was found between RFP and SFP in overall muscle activation ($p > 0.05$).

DISCUSSION

In a previous study, the effects of elbow position in the sagittal plane on the activity of biceps and triceps brachii were investigated^{7, 8)}. In this study, we examined the effects of elbow position in the frontal plane on the activity of the biceps and triceps brachii. Although the difference did not achieve significance, medial muscle activation was higher in the SFP than in the RFP in both muscles. We hypothesized that the SFP would produce symmetrical activation of the medial and lateral muscles, but in fact, the activation between the muscles was more asymmetrical than that seen for the RFP. Difference of two positions in CA less affected muscle length and selective activation. We need to examine of changes in activation of all of upper arm flexor and extensors during strengthening exercise should assess in future studies. Because the primary elbow flexors are the biceps brachii, brachialis and brachioradialis, and the primary elbow extensors are the three heads of the triceps brachii and the anconeus⁴⁾. This study had a limitation in that the standard deviation between raters was large for CA measurements obtained with the digital inclinometer. Thus, a more reliable method for measuring the CA is required.

In summary, as the CA of the elbow joint decreased, the medial muscles of the biceps and triceps brachii muscles showed greater activity than the lateral muscles; thus, there was difference in activation between the medial and lateral muscles depending on the exercise starting position. However, there were no significant differences in overall muscle activation between the RFP and SFP, CA less affected to biceps and triceps muscle activation during upper arm strengthening exercises.

Conflict of interest

None.

REFERENCES

- 1) Paraskevas G, Papadopoulos A, Papaziogas B, et al.: Study of the carrying angle of the human elbow joint in full extension: a morphometric analysis. *Surg Radiol Anat*, 2004, 26: 19–23. [Medline] [CrossRef]
- 2) Koo TK, Mak AF: Feasibility of using EMG driven neuromusculoskeletal model for prediction of dynamic movement of the elbow. *J Electromyogr Kinesiol*, 2005, 15: 12–26. [Medline] [CrossRef]
- 3) Allouh MZ, Abu Ghaida JH, Jarrar AA, et al.: The carrying angle: racial differences and relevance to inter-epicondylar distance of the humerus. *Folia Morphol (Warsz)*, 2016, 75: 388–392. [Medline] [CrossRef]
- 4) Neumann DA: *Kinesiology of the musculoskeletal system-e-book: foundations for rehabilitation*. Elsevier Health Sciences, 2013.
- 5) Ahamed NU, Sundaraj K, Ahmad RB, et al.: Analysis of right arm biceps brachii muscle activity with varying the electrode placement on three male age groups during isometric contractions using a wireless EMG sensor. *Procedia Eng*, 2012, 41: 61–67. [CrossRef]
- 6) Kim S, Lee W, Ha S, et al.: A comparison of EMG activity for long and lateral heads of triceps brachii muscles according to exercise and forearm positions during triceps strengthening exercises. *Phys Ther Korea*, 2011, 18: 28–36.
- 7) Ali A, Sundaraj K, Badlishah Ahmad R, et al.: Muscle fatigue in the three heads of the triceps brachii during a controlled forceful hand grip task with full elbow extension using surface electromyography. *J Hum Kinet*, 2015, 46: 69–76. [Medline] [CrossRef]
- 8) An KN, Kaufman KR, Chao EY: Physiological considerations of muscle force through the elbow joint. *J Biomech*, 1989, 22: 1249–1256. [Medline] [CrossRef]