Comparison of Effects of Pincer- and Scissor-pinching Modes of Chopstick Operation on Shoulder and Forearm Muscle Activation during a Simulated Eating Task

IN-GYU YOO¹⁾, WON-GYU YOO²⁾

¹⁾ Department of Occupational Therapy, College of Alternative Medicine, Jeonju University

²⁾ Department of Physical Therapy, College of Biomedical Science and Engineering, Inje University & Elderly Life Redesign Institute: 607 Obangdong, Gimhae 621-749 Gyeongsangnam-do, Republic of Korea. TEL: +82 55-320-3994, FAX: +82 55-329-1678, E-mail: won7y@inje.ac.kr

Abstract. [Purpose] This study investigated the best training method for chopsticks manipulation through a comparison of muscle activations of the shoulder and forearm between pincer-pinching and scissor-pinching operations. [Subjects] Thirteen participants were recruited. [Methods] They performed simulated eating tasks using two different chopstick operations. The EMG activities of the right side upper trapezius, flexor and extensor carpi radialis were measured. [Results] Electromyographic activity of the upper trapezius muscles was significantly lower in scissor-pinching than in pincer-pinching. The activity of the flexor carpi radialis muscle was significantly higher in scissor-pinching than in pincer-pinching. [Conclusion] We consider that persons with fine-motor impairment of the hands would be able to use chopsticks more effectively if the chopsticks operation were properly selected.

Key words: Chopsticks operation, Flexor carpi radialis, Upper trapezius

(This article was submitted Apr. 26, 2012, and was accepted May 19, 2012)

INTRODUCTION

Using chopsticks allows people to extend their hand skills. The convenience and efficiency of chopsticks have recently increased interest in their use¹⁻³⁾. Using a pair of chopsticks for dining is regarded as an important part of social life in Asia^{4, 5)}. One of the most important functions of the hands is the gripping and manipulation of chopsticks. These movements require greater dexterity and a longer time to learn and practice compared with other eating utensils. Generally, chopsticks operation is classified into pincer-pinching and scissor-pinching operations. Both operations demand good neural control and fine-motor function of the fingers, including movement of the thumb, index finger, and middle fingers⁶⁾. In previous studies, pincer pinching was shown to require higher precision and stability than other operations. Pincer-pinching is classified as a third-class lever. It is a skillful movement in which one stick is held stationary while the other stick is moved in a dynamic tripod grasp³⁾. In contrast, scissor-pinching involves a first-class lever. Although this operation is inferior to pincer pinching in precision and stability, it is more powerful because of its greater mechanical advantage and the fact that palm grasp force can be used⁷⁾. This study investigated the most efficient training method for chopsticks manipulation through a comparison of shoulder and forearm muscle activation in pincer-pinching and scissor-pinching operations.

SUBJECTS AND METHODS

The subjects of this study were 13 asymptomatic participants aged 21.6 ± 3.4 (mean $\pm$ SD). Their mean heights and weights were 172.3 ± 12.3 cm and 64.6 ± 8.4 kg, respectively. All participants were right-hand dominant, and none had symptoms of upper extremity discomfort or a history of musculoskeletal dysfunction within the last 6 months. All participants gave their written informed. The chopsticks used a pair of traditional bamboo chopsticks, 240 mm in length, square in the handle and round at the tip. The width of the square handle was 6×6 mm in cross-section, and the round tip was 4 mm in diameter, with a two-degree tip angle. Simulated food in the form of rubber cubes ($10 \times 10 \times 10$ mm) was used. Surface electromyography signals were collected using a Trigno wireless system (DelSys, Boston, MA, USA). The sEMG signals were digitally recorded at a sample rate of 1000 Hz, and the root mean square was calculated using EMG works 4.0 analysis software. Wireless surface electrodes were attached parallel to each muscle fiber on the nondominant side of the muscles: upper trapezius, extensor carpi radialis, and flexor carpi ulnaris⁸⁾. For normalization, maximum voluntary isometric contraction was determined for each subject. Each subject was instructed to use bamboo chopsticks to pick up the simulated food in pincer-pinching and scissor-pinching chopstick operation modes with their nondominant hand. We selected the nondominant hand to compare the difference of hand skill⁹⁾. Subjects attempted

to pick up 10 rubber cubes from a paper plate (215 mm in diameter) and placed them into a paper cup (70 mm in diameter) located just below the level of the mouth. The travel distance was 300 mm between the center of the dish and the center of the cup in the horizontal axis and 250 mm between the plate and the upper brim of the cup in the vertical axis¹¹. The raw EMG data were recorded from the time the first piece of rubber was placed into the cup until the last piece was placed. The SPSS statistical package (SPSS, Chicago, IL, USA) was used to perform statistical analyses. The significance of differences between the two chopstick operations during the simulated eating was determined by the paired t-test. Statistical significance was accepted for values of $p < 0.05$.

RESULTS

The upper trapezius muscle activity was significantly lower during scissor-pinching ($8.10 \pm 3.77\%$) than during pincer-pinching ($10.84 \pm 5.27\%$) ($p < 0.05$). The flexor carpi radialis muscle activity was significantly higher during scissor-pinching ($13.07 \pm 5.37\%$) than during pincer-pinching ($9.61 \pm 4.86\%$) ($p < 0.05$). The activity of the extensor carpi ulnaris muscle showed no significant difference between the two operations (pincer-pinching 11.83 ± 5.10 , scissor-pinching 14.19 ± 5.66).

DISCUSSION

To reach a high performance level in terms of pinching function, time and effort are required to practice the skill of manipulation^{10, 11}, and chopsticks should be the preferred eating utensils throughout life. This study found that upper trapezius muscle activation during pincer pinching is greater than that during scissors-pinching. The upper trapezius muscle has been closely associated with shoulder muscle pain in studies of musculoskeletal disease in the upper extremities. In particular, persons with fine-motor impairment of the hands are unable to produce balanced muscle power between agonist and antagonist muscles. Moreover, awkward postures may cause them to use more force. Continuous use of the muscle in this way may result in myofascial pain syndrome in the shoulder^{12, 13}. The flexor carpi radialis muscle during scissor-pinching was greater than that during pincer-pinching. This muscle is involved in flexion of the forearm, or curling the palm side of the wrist inward toward the elbow^{9, 14}. Thus, our finding might demonstrate that scissor-pinching uses the simple action of a power grip more than fine-motor function of the fingers. This mechanical advantage may benefit patients with fine-motor impairment of the hands who do not have skillful hand manipulation¹⁵. No significant difference in EMG activity in the extensor carpi ulnaris muscle was found between pincer-and scissor-pinching. The absence of significant differences in activation of this muscle may reflect the fact

that sustained finger extension is not required for operating chopsticks during eating.

Previous studies have found that half of chopsticks operations were pincer-pinching, and the other half were scissor-pinching^{1, 3}. These previous studies indicated that the different chopstick operations did not influence discomfort during eating. Chen¹¹ noted that pincer-pinching is superior to scissor-pinching in terms of pinching precision and stability, but it is inferior in terms of pinching force. The results of our present study may be of help in the chopstick operation of persons with fine-motor impairment of the hands, who lack skillful hand manipulation and power, and who may experience difficulty with the use of chopsticks for dining. We consider that persons with fine-motor impairment of the hands would be able to use chopsticks more effectively if the chopsticks operation were properly selected. This study had some limitations. We didn't measure the length of the fingers of each participant. Also, significant differences were found in the muscle activities, but the absolute differences were small.

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