Comparison of Muscle Activation while Performing Tasks Similar to Activities of Daily Livings with and without a Cock-up Splint

HYE-YOUNG JUNG¹⁾, NAM-HAE JUNG²⁾, MOON-YOUNG CHANG^{3)*}

¹⁾ Department of Occupational Therapy, Suncheon First College, Republic of Korea

²⁾ Department of Rehabilitation Science, Graduate School of Inje University, Republic of Korea

³⁾ Department of Occupational Therapy, College of Biomedical Science and Engineering, Inje University:197 Inje Street, Gimhae, Gyeongsangnam-do 621-749, Republic of Korea

Abstract. [Purpose] This study investigated changes in the activation of the main elbow muscle while performing tasks similar to activities of daily living (ADL) with and without a cock-up splint. [Methods] Sixteen participants performed a simulated feeding task and picked up light and heavy cans in the Jebsen-Taylor hand function test. The activation of the biceps brachii, the triceps brachii, and the brachioradialis with and without the cock-up splint was measured using a BTS FreeEMG 300 wireless electromyography system (BTS, Inc., Milan, Italy). [Results] The activation of the biceps brachii and the brachioradialis was significantly higher while performing the simulated feeding task with the cock-up splint than without the splint. While picking up the light and heavy cans, the activation of the brachioradialis was significantly decreased by wearing the cock-up splint. In the heavy cans task, the activation of the triceps brachii was significantly higher with the cock-up splint than without the splint. [Conclusion] This study showed that diverse muscles' activation was increased or decreased when wearing the cock-up splint while performing tasks similar to ADL. The results of this study can be used as an educational resource for therapists teaching patients about splint application and splint compliance in ADL.

Key words: Cock-up splint, Jebsen-Taylor hand function test, Muscle activation

(This article was submitted Apr. 15, 2013, and was accepted May 15, 2013)

INTRODUCTION

Splinting has been an important intervention in occupational therapy since at least the mid-20th century¹⁾. It has been applied as a nonsurgical intervention method to treat rheumatoid arthritis or osteoarthritis, and carpal tunnel syndrome, and affects the wrist movements^{2–4)}. The cock-up splint is one of the most widely used wrist splints. It protects impaired tissue, relieves pain, stabilizes or immobilizes the joint, corrects or prevents deformity, and recovers function by minimizing the activation of the wrist muscle⁵⁾.

Movements of the wrist are associated with movement of the elbow and the shoulder^{3, 6)}. The application of a cock-up splint to restrict movement of the wrist can cause upper extremity pain^{7, 8)}. Although there are many studies on the range of motion and muscle activation of the shoulder joint while wearing a cock-up splint^{9, 10)}, studies of the activation of the elbow muscle are lacking.

The purpose of this study was to investigate the change in the activation of the main elbow muscles while performing tasks similar to ADL with and without application of a cock-up splint.

SUBJECTS AND METHODS

This experiment was conducted at “I” university in the Republic of Korea in December 2011. The 16 participants (9 women and 7 men) voluntarily agreed to participate in the study. They had no musculoskeletal problems of the upper extremity or hands. Their average age was 21.6 ± 1.4 years old, and their average height was 166.6 ± 9.4 cm. All the participants read and signed an informed consent form, and the Inje University Ethics Committee for Human Investigations provided ethical approval for this study prior to their participation.

A wireless electromyography BTS FreeEMG 300 measurement system (BTS, Inc., Milan, Italy) was used to compare the muscle activations with and without the cock-up splint. Super-light 8.5g wireless electrodes were used, with a maximum indoor transfer distance of 50 m. The system features an A/D converter within an EMG sensor. Thus, noise is very rare. The Wi-Fi EMG system has eight channels for collecting wireless data. To measure the activation of the elbow muscle, the electrodes were placed on the elbow flexors the biceps brachii and the brachioradialis – and on the elbow extensor, the triceps brachii, as per the method of Cram, Kasman and Holtz¹¹⁾ (Fig. 1). To reduce the resistance of the skin to the electromyographic signal, the forearms of the participants were shaved to remove hair, then cleaned with an alcohol swab. The same person attached all

*To whom correspondence should be addressed.
E-mail: myot@inje.ac.kr

the electrodes. The sampling frequency was 1,000 Hz. The measured raw data were band-pass filtered at a bandwidth of 20–500 Hz, and the collected signals were analysed and the RMS (Root Mean Square) value was calculated.

The tasks selected for this study were simulated feeding and, picking up light and heavy cans in the Jebsen-Taylor hand function test. The Jebsen-Taylor hand function test consists of tasks similar to ADL, and is a standardized evaluation of hand function¹²⁾. Feeding is the most frequent ADL. Picking up light and heavy cans enables investigation of the difference in muscle activation dependent on weight. The order of the three evaluation tasks was randomized, and the participants were allowed a 5 min. break between each task.

The splints used in this study were made from a low-temperature thermoplastic aquaplast of 0.32 mm thickness (Sammons Preston Rolyan, USA). They were customized to the forearm and the hand of the participants and covered two-thirds of the length of the forearm on the volar side. The weight of the splint ranged from 90 to 120g depending on hand and forearm size. In general, the angle of wrist extension in a splint depends on the disease. The wrist position of the cock-up splint for carpal tunnel syndrome is a neutral position, for radial nerve palsy it is 15–30° wrist extension, and for wrist synovitis it is 0–15° wrist extension. In this study, the angle of wrist extension of the cock-up splint was 30° in consideration of the functional position of wrist being 20–30° wrist extension¹³⁾. The participants were asked to sit at a table, which could be adjusted to indi-

vidual work heights with their shoulders relaxed and their elbows resting on the table.

Data were statistically analyzed with the statistics package SPSS 18.0 for Windows, and the significance level in all the analyses was 0.05. The paired t-test was used to compare the muscle activations between wearing and not wearing the splint.

RESULTS

In the simulated feeding task, the activations of the biceps brachii and the triceps brachii were 11.63% MVC% (Maximum voluntary contraction percent) and 3.59 MVC%, respectively, when not wearing the splint, and 14.63 MVC% and 4.31 MVC% when wearing the splint, statistically significant differences ($p < 0.05$). Activation of brachioradialis was 12.31 MVC% without the splint and 14.15 MVC% when wearing the splint, revealing no significant difference ($p > 0.05$) (Table 1). When picking up the light cans, the activation of the brachioradialis was 31.13 MVC% when not wearing the splint, and 26.66 MVC% when wearing the splint, a statistically significant decrease ($p < 0.05$). There were no significant differences in the biceps and triceps brachii between wearing and not wearing the splint ($p > 0.05$) (Table 1). In picking up the heavy cans, the activation of the triceps brachii and the brachioradialis was 10.65 MVC% and 36.70 MVC%, respectively, when not wearing the splint, and 35.79 MVC% and 27.77 MVC% when wearing the splint. The difference was significant ($p > 0.05$). However, the activation of the biceps brachii showed no significant difference between with and without the splint ($p > 0.05$) (Table 1).

DISCUSSION

Splinting is one of the most important treatments for minimizing dysfunction of the hand and restoring function of the hand¹⁴⁾. From the point of view of a patient, the best functional outcome when wearing a splint is independent performance in ADL, work and leisure activities. However, a splint only tends to the damaged tissues and joints¹⁵⁾. Many patients stop wearing splints because of discomfort or pain, time restrictions, forgetfulness, or interference

Fig. 1. Attachment of the surface electrodes for simulated feeding with a cock-up splint

Table 1. Comparison of muscle activations without and with the splint (unit: MVC%)

Muscle		Not wearing a splint (Mean ± SD)	Wearing a splint (Mean ± SD)
Simulated feeding	Biceps brachii*	11.63 ± 6.81	14.63 ± 8.38
	Triceps brachii*	3.59 ± 1.54	4.31 ± 1.85
	Brachioradialis	12.31 ± 8.49	14.15 ± 7.59
Picking up light cans	Biceps brachii	14.89 ± 7.54	16.46 ± 9.61
	Triceps brachii	9.15 ± 8.00	10.71 ± 10.58
	Brachioradialis*	31.13 ± 20.03	26.66 ± 17.34
Picking up heavy cans	Biceps brachii	21.76 ± 22.25	19.50 ± 11.68
	Triceps brachii*	10.65 ± 10.76	35.79 ± 21.25
	Brachioradialis*	36.70 ± 21.68	27.77 ± 20.58

* $p < 0.05$

with daily routines¹⁶). To prevent noncompliance, the therapist needs to educate patients and their families about these problems before applying the splint.

The purpose of this study was to compare elbow muscle activations while wearing and not wearing a cock-up splint during tasks similar to ADL. The hypothesis of this study, based on previous research, was that the activation of the main elbow muscles would be significantly increased with the cock-up splint while performing such tasks.

During the simulated feeding, the activation of the biceps and the triceps brachii increased significantly when wearing the cock-up splint compared to without the splint. Previous work has shown that during drinking, which is similar to feeding, the biceps are associated with the triceps brachii at every stage of the drinking motion, supporting an important interrelationship between the biceps and triceps during drinking¹⁷). In the same vein, activities of the biceps and the triceps were affected by wrist immobilization during the simulated feeding in the present study. Picking up a can involved extending the arm and releasing the can on a board. During this activity, the activation of the brachioradialis was significantly decreased while wearing the cock-up splint compared to when not wearing the splint. According to one study, the activation of the brachioradial is related to wrist extension¹⁸), because it protects the wrist joint during the repetitive pick-up and release motion. In contrast to picking up a light can, the activation of the triceps with the cock-up splint increased significantly when picking up a heavy can. We think this is due to the weight difference of the cans. The difference in triceps brachii activation between lifting light and heavy cans while wearing a cock-up splint was 25.08 MVC%; on the other hand, the difference in triceps brachii activation without the cock-up splint was only 1.51 MVC%. We consider a small weight can lead to a large change activation of main action muscle when wearing a cock-up splint. Our findings show that the activation of the main elbow muscles when wearing a cock-up splint differs depending on the task.

Patients are required to wear these splints for extended periods. During this time, independent performance of ADL without stress is very important as well as the prevention of damage to tissues and joints. A biopsychosocial orthotic approach to splint application emphasizes the importance of designing interventions that include patient involvement and holistic considerations of individuals' unique attributes, context, and environment¹⁹). Kim et al.¹⁰) reported that muscle fatigue differs over time. Thus a daily schedule for splint compliance and a daily occupation schedule while wearing a splint would help to reduce muscle fatigue. The

results of this study can be used as an educational resource for therapists teaching patients splint application and about splint compliance in ADL.

ACKNOWLEDGEMENT

This work was supported by the 2012 Inje University research grant.

REFERENCES

- 1) Fess EE: A history of splinting: to understand the present, view the past. *J Hand Ther*, 2002, 15: 97–132. [Medline] [CrossRef]
- 2) Kruger VL, Kraft GH, Deitz JC, et al.: Carpal tunnel syndrome: objective measures and splint use. *Arch Phys Med Rehabil*, 1991, 72: 517–520. [Medline]
- 3) Linden CA, Trombly CA: Orthoses: Kinds and purposes. In C.A. Trombly (Ed.), *Occupational therapy for physical dysfunction*, 4th ed. Baltimore: Williams & Wilkins, 1995, pp 551–581.
- 4) Ouellette EA: The rheumatoid hand: orthotics as preventative. *Semin Arthritis Rheum*, 1991, 21: 65–72. [Medline] [CrossRef]
- 5) McKee P, Morgan L: *Orthotics in rehabilitation: Splinting the hand and body*. Philadelphia: FA Davis, 1998.
- 6) Safaee-Rad R, Shwedyk E, Quanbury AO, et al.: Normal functional range of motion of upper limb joints during performance of three feeding activities. *Arch Phys Med Rehabil*, 1990, 71: 505–509. [Medline]
- 7) Adams BD, Grosland NM, Murphy DM, et al.: Impact of impaired wrist motion on hand and upper-extremity performance. *J Hand Surg Am*, 2003, 28: 898–903. [Medline] [CrossRef]
- 8) Perez-Balke G, Buchholz B: Role of wrist immobilization in the work environment: ergonomics and carpal tunnel syndrome. *Work*, 1994, 4: 187–194.
- 9) Mell AG, Friedman MA, Hughes RE, et al.: Shoulder muscle activity increases with wrist splint use during a simulated upper-extremity work task. *Am J Occup Ther*, 2006, 60: 320–326. [Medline] [CrossRef]
- 10) Kim M, Roh JS, Cynn HS, et al.: The effect of cock-up splinting on upper extremity muscle fatigue during keyboard typing. *J Korean Acad Univ Trained Phys Therapists*, 2008, 5: 73–80.
- 11) Cram JR, Kasman GS, Holtz J: *Introduction to surface electromyography*. Gaithersburg, Maryland: Aspen Publishers, 1998.
- 12) Sears ED, Chung KC: Validity and responsiveness of the Jebsen-Taylor hand function test. *J Hand Surg [Br]*, 2010, 35A: 30–37.
- 13) Coppard BM, Lohman H: *Introduction to splinting: A clinical reasoning and problem-solving approach*, 3rd ed. Mosby Elsevier, 2008.
- 14) McKee K, Rivard A: Orthoses as enablers of occupation: client-centered splinting for better outcomes. *Can J Occup Ther*, 2004, 71: 306–314. [Medline] [CrossRef]
- 15) Stegink Jansen CW, Olson SL, Hasson SM: The effects of use of a wrist orthosis during functional activities on surface electromyography of the wrist extensors in normal subjects. *J Hand Ther*, 1997, 10: 283–289. [Medline] [CrossRef]
- 16) Kirwan T, Tooth L, Harkin C: Compliance with hand therapy programs: therapists' and patients' perceptions. *J Hand Ther*, 2002, 15: 31–40. [Medline] [CrossRef]
- 17) Yun SY, Lee TY, Park SY, et al.: Muscle activity and a kinematic analysis of drinking motion. *J Korean Soc Occup Ther*, 2008, 16: 77–88.
- 18) Freehafer AA: Tendon transfers in tetraplegic patients: the Cleveland experience. *Spinal Cord*, 1998, 36: 315–319. [Medline] [CrossRef]
- 19) McKee PR, Rivard A: Biopsychosocial approach to orthotic intervention. *J Hand Ther*, 2011, 24: 155–162. [Medline] [CrossRef]