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Original Article

3D motion analysis of the wrist splint effect to wrist joint movement

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Abstract. [Purpose] This study aimed to investigate the degree of straightness of the wrist joint, depending on the use of a wrist splint while opening a bottle cap. Its results may provide data for later studies on preventing accidents at workplaces and improving efficiency. [Subjects and Methods] Thirty Male and Female in their twenties who did not have hand-related diseases, fractures, or history that included neurological impairments associated with the hand were selected as subjects of the study. Wrist splints were made to fit the hand and lower arm of each subject. Evaluation assignments were carried out without and with the splints after 10 minutes of rest. To analyze the wrist movement in opening the bottle cap, a three-dimensional movement analyzing system by Zebris was used. [Results] Wrist angle decreased while opening caps of four different diameters while wearing splints, but not when splints were not worn. This means that wearing a splint may aid weakened wrist muscles. [Conclusion] Future studies should be conducted among subjects with damaged wrist muscles and evaluate the subjects in actual workplaces to obtain more objective and more valid data.

Key words: Wrist splint, 3-D motion analysis, Industrial accidents

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INTRODUCTION

With the current industrial development, modern society not only provides many conveniences but also confers risks of endless industrial accidents[1)]. In their daily lives, people are exposed to various risks of death-causing illnesses or injuries, which lead to actual economic losses or reduced productivity[2)].

No one is free from such risks, and when such incidents occur at workplaces, they are called industrial accidents[3)]. Approximately 80% of musculoskeletal disorders occur at workplaces according to an industrial accident analysis by the Ministry of Employment and Labor[4)]. The statistical data on industrial accidents published each year provide basic data for various types for accidents to be used in establishing policies of industrial accident prevention. For proper industrial accident prevention activities and the evaluation of such activities, accident inducing environments should be analyzed from different angles[5)]. With industrialization and its development, the incidence of hand injuries from industrial accidents is increasing. Subjects who incur hand injuries are mostly of economically productive age. Injuries affect not only the patients themselves but also the livelihood of their families. They feel that they are relatively disadvantageous socially and economically. They also seem to develop psychological and mental problems[6)]. The hand being an important part of the body has important functions thus its surgical treatment accounts for most hand injury treatments, which has helped the development of surgical procedures and related treatments[7)]. A flexor muscle around the wrist controls it. However with a wrist injury, the extensor muscle is weakened because of repeated extension activities while working or in leisure activities. Extended use of the extensor muscle or excessive strain while moving heavy object will weaken the strength and endurance of the wrist[8)]. As a treatment of hand injury, a wrist splint may be used. The wrist splint was one of the most important interventions for

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minimizing dysfunction and restoring function of the hand[9]. The wrist splint supports the wrist and maintains and protects it through its springy function[10]. It also helps improve bodily functions and slows down the advancement of conditions. Thus, it helps reduce pain, limits the movement of unstable joints and distributes stress from weight[11]. Use of a wrist splint will not eliminate the causes of musculoskeletal disorders, but may prohibit the use of the upper extremities temporarily to reduce secondary risks. The present study involved the use of bottle caps of various sizes. Wrist angles and movements while turning caps were measured for three-dimensional analysis.

This study was conducted to investigate the degree of straightness of the wrist joint, depending on the use of a wrist splint while opening a bottle cap. The data obtained from the study may be useful for future studies on prevention of industrial accidents and improvement of productivity.

SUBJECTS AND METHODS

Thirty Male and Female in their twenties who did not have hand-related diseases, fractures, or history that included neurological impairment associated with the hand were selected as study subjects. The study objectives were explained to the study subjects to obtain their consent. To prevent risks of wrist injuries, the present study involved the uses of the bottle cap-opening activity to investigate the degrees of wrist extension. To analyze the wrist movement in opening the bottle cap, a three-dimensional movement analyzing system by Zebris was used. This device can detect signals from indicators as small as 1 cm in diameter for measurement of wrist angles. The indicators are mounted on the metacarpophalangeal joint of the index finger, the midpoint of the radial and ulnar fibulae, and on the lateral epicondyle.

Wrist splints were made to fit the hand and lower arm of each subject. Evaluation assignments were carried out without and with the splints after 10 minutes of rest. Evaluations were conducted by an expert therapist. Descriptive statistics and correlation analysis of data were performed by SPSS 19.0. All the subjects understood the purpose of the study and provided their written informed consent prior to participation in the study in accordance with the ethical principles of the Declaration of Helsinki.

RESULTS

The general characteristics of the study subjects were as the follows: 4 Male (13.3%) and 26 Female (86.7%); 29 had a dominant right hand (96.7%) and one had a dominant left hand (3.3%); the mean ages was 23.43 ± 3.23 years (Table 1).

Comparisons between before and after the use of wrist splints were as follows: for the case of a 2-cm-diameter cap, the without the wrist angle was −2.45 ± 4.98 without a splint and 6.92 ± 7.81 with a splint, showing a significant increase ($p<0.01$); in the case of 4-cm-diameter cap, the wrist angle was −0.58 ± 7.72 without a splint and 7.69 ± 8.07 with a splint, showing a significant increase ($p<0.01$); in the case of a 6-cm-diameter cap, the wrist angle was −2.63 ± 4.85 without a splint and 8.61 ± 10.26 with a splint, showing a significant increase ($p<0.01$); and in the case of a 10-cm-diameter cap, the wrist angle was −0.79 ± 6.24 without a splint and 9.29 ± 10.63 with splint, showing a significant increase (Table 2).

Table 1. General characteristics of survey participants

Category		Frequencies	%
Gender	Male	4	13.3
	Female	26	86.7
Dominant hand	Right	29	96.7
	Left	1	3.3
Mean age		23.43 ± 3.23	

Table 2. Comparisons of before and after the use of wrist splint

	Before	After	t
2 cm diameter	−2.45 ± 4.98	6.92 ± 7.81	−4.63**
4 cm diameter	−0.58 ± 7.72	7.69 ± 8.07	−3.28**
6 cm diameter	−2.63 ± 4.85	8.61 ± 10.26	−4.42**
10 cm diameter	−0.79 ± 6.24	9.29 ± 10.63	−5.07**

**$p<0.01$

DISCUSSION

Most workers generally use the flexor muscle more than the extensor muscle in movements that require wrist activity, which may lead to increased hand injuries. To prevent risks of wrist injuries, the present study involved the uses of the bottle cap-opening activity to investigate the degrees of wrist extension. As the analysis of cap-opening activities with or without splints demonstrated significant differences in joint angles, it is apparent that the splint influences the cap opening activity ($p<0.01$). This means that wrist splints may aid weakened extensor muscles. Therefore, for work-related hand injuries, wearing splints will aid the weakened extensor muscles.

Kim[12] used splints manufactured in the West in his study. By contrast, in the present study, we used a customized splint for the evaluation so that more accurate joint movements could be observed. Kim[12] performed measurements by using only electromyograms (EMG) in that study, whereas in the present study, we used a three-dimensional movement analyzer for more-accurate joint movement observations.

Yu et al.[13] investigated wrist movements in their study, but the movements were limited to turning screws which did not provide data for various movements. Their analysis was based on EMG data, which only measured the use of muscles.

As the subjects of the present study were few, the results are not easy to generalize. In the investigation for damages of the extensor muscle, the subjects were found to have normal rather than injured wrists. Therefore, further studies on injured wrists are required to investigate the effects of wearing wrist splints. Furthermore, future studies should evaluate actual wrist movements at the workplace.

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