Applied Mechanics and Materials Vols. 465-466 (2014) pp 1170-1174
Online available since 2013/Dec/19 at www.scientific.net

doi:10.4028/www.scientific.net/AMM.465-466.1170

Applying Clockwise and Counterclockwise Torque Directions in Pinch Grips: A Descriptive Study

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Keywords: Clockwise, Counterclockwise, Torque direction, Pinch grip, Descriptive, Ergonomics

Abstract. Hand and finger-related injuries are increasingly common in the manufacturing industry. In relation to this, researchers have conducted various studies and found that a clockwise torque can produce a greater grip force than a counterclockwise torque direction, hence improving the grip control and exertion of an individual. However, there appears to be limited studies that explore this theory in the circumstances of pinch grips. Thus, the aim of this study is to explore the effects of different torque directions on the pinch grips. 6 prototype industrial screw knobs were designed, produced and evaluated by surveying 160 workers from a manufacturing firm. The results show that although the sizes are different, the effort to turn the knobs with a counterclockwise torque direction is still greater than the effort with a clockwise torque direction, which can technically mean that the pinch exertion in a clockwise torque direction is relatively greater. Based on these findings, guidelines can be developed to further improve hand tool designs and the capacity of torque exertions to potentially increase human performance and the effectiveness in tasks at the workplace.

Introduction

Work-related injuries and musculoskeletal disorders have been increasingly prevalent in the manufacturing industry [1] hence increasing the concerns from employees, employers and the government. In relation to this, it was found that 1.08 million people are treated for work-related finger and hand injuries in each year [2]. Since hand injuries can greatly influence a person's daily activities, an in-depth understanding of the reasons behind them is important [3-5]. Previously, many researchers found the causal factors of hand-related injuries to be high force grip exertions, repetitive movements and poor hand postures [6-10]. Some researchers also believe that torque exertions are important in handgrip activities [3, 8, 11, 12]. In a grip and twist action, a clockwise torque can produce a greater grip force than a counterclockwise torque direction [3, 8, 11, 12]. However, this notion has yet to be confirmed under the circumstances of pinch grip applications. Therefore, this study aims to explore the effects of different torque directions on the pinch grips.

Pinch Grips and Torque Direction

Pinch grips are mainly used in daily activities. A basic example of a pinch grip activity is the act of holding a small object (such as a pencil) and manipulating it for a certain purpose (such as writing). Although pinch grips appear to be simple tasks, understanding the way objects are pinched and the types of hand movements administered during a pinch activity are important factors that can potentially influence the level of injury prevention at the workplace [13-15].

Hand torque can be applied in two directions namely clockwise and counterclockwise directions. Clockwise torque is defined as the twisting movement of the hand towards the inner forearm direction, whereas the counterclockwise torque is defined as the twisting movement of the hand towards the outer forearm direction [8, 12]. A high amount of hand torque can be generated in a clockwise direction as compared to a counterclockwise direction [3, 16] which can be somehow be related with the action of unscrewing the lid of a jar or turning a doorknob [3]. According to Seo, et al. [11], a clockwise torque can exert a greater force than a counterclockwise torque.

Research Method

For this study, 6 prototype industrial screw knobs were designed and produced. 3 types of screw knobs (3 different shapes, with 2 sizes per shape) that are commonly used in various industries were developed for this study. These knobs include round, ball and star-shaped knobs [17]. These 6 knobs were attached to their corresponding housings and mounted on a rigid frame. The three designs have two different sizes. The smaller size is 10mm while the bigger size is 63mm.

The participants were required to conduct some tests with these 6 industrial screw knobs and answer some questions from the survey. Immediately after every trial run in the experiment, the participants were required to provide their ratings for a question from the survey based on their perception [18]. The survey consists of close-ended questions with a psychophysical ratio-scale. The scale used is a modified version of the Borg CR10 scale [18]. The scale ratings range from 0 to 10. The rating 0 indicates that there is no effort required for this activity at all, whereas the rating 10 indicates that there is a tremendous effort required for the activity [18]. This study involved the participation of 160 male manual workers. The workers were from a manufacturing firm that produces furniture and wooden pallets in Penang, Malaysia. The age of the participants ranges from 18 to 65 years old. All of them are right handed and free from any form of hand injuries.

This data collection took approximately 3 days, with a participation of 40 workers per day and a 10 minute duration for each worker to complete the experiment. The pinch grip exertions were performed with the right hand as demonstrated in the research of Seo, et al. [12]. The test model was positioned on the table so that the workers could be stand straight facing the model with their elbow flexed at a 90° angle. Every participant was presented with the test model and asked to pinch the screw knobs by using a certain pinch technique. The participants were then requested to turn the screw knob with a clockwise and counterclockwise directions. This step was repeated with the rest of the other screw knobs. In this research, 3 pinch techniques are used to test the effort to turn the knob with clockwise and counterclockwise torque directions, namely the three jaw chuck, pulp-2 and lateral pinch techniques.

Upon the completion of the turning activity, a question was asked from the survey and the worker was required to rate the turning effort of the knob. Their ratings were recorded in a feedback form. A total of 110 usable survey data were collected out of 160 survey data from 160 workers from the manufacturing firm. The response rate is 67.85%, which is an acceptable response rate in most studies [19]. After compiling all the data, the results were analyzed descriptively using Microsoft Excel 2010. The Cronbach's alpha reliability, mean, maximum and minimum analyses were used to generate the results.

Results and Discussion

The overall Cronbach's alpha obtained for this study was 0.906, a value adequately above 0.7. A Cronbach's alpha coefficient above 0.7 would signify high reliability and excellent internal consistency of the data [20]. Thus, the data for this study is considered reliable for further analyses. Figure 1 shows the mean effort rating to turn samples 1(a), 2(a) and 3(a) which are in size 1. Sample 1(a) represents the small round knob, whereas samples 2(a) and 3(a) represent the small ball and star shaped knobs.

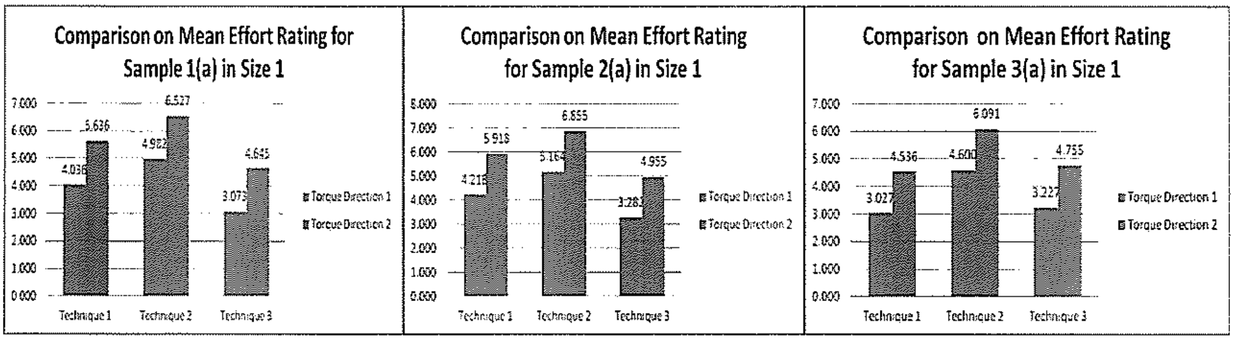

Figure 1: The Comparison on Mean Effort Rating for Size 1

Sample 1(a). Technique 1 which is the three jaw chuck pinch was used to turn the knob. The mean effort rating to turn the knob with a clockwise torque direction is 4.036 with the use of the three jaw chuck pinch. Technique 2 which is pulp-2 pinch was also used to turn the knob. The mean effort rating to turn the knob with a clockwise torque direction is 4.982 whereas the mean effort rating to turn the knob with a counterclockwise torque direction is 6.527. Based on the abovementioned results, it appears that the counterclockwise torque direction requires more effort than the clockwise torque direction to turn the knob, regardless of the different techniques used.

Sample 2(a). Technique 1 which is the three jaw chuck pinch was used to turn the knob. When using the technique 1, the mean effort rating to turn the knob with a clockwise torque direction is 4.218. Technique 2 which is the pulp-2 pinch was also used to turn the knob. The mean effort rating to turn the knob with a clockwise torque direction is 5.164 whereas the mean rating to turn the knob with a counterclockwise torque direction is 6.855. Technique 3 which is the lateral pinch was also used to turn the knob. The mean effort rating to turn the knob with a clockwise torque direction is 3.282 while the mean effort rating to turn the knob with a counterclockwise torque direction is 4.955. According to the preceding analyses, it is found that the clockwise torque direction once again requires less pinch-and-turn effort compared to the counterclockwise torque direction.

Sample 3(a). Technique 1 which is the three jaw chuck pinch was used to turn the knob. The mean effort rating to turn the knob by using the three jaw chuck pinch with a clockwise torque direction is 3.027. While using the pulp-2 pinch (Technique 2), the mean effort rating to turn the knob with a clockwise torque direction is 4.600 whereas the mean effort rating to turn the knob with a counterclockwise torque direction is 6.091. For Technique 3 which is lateral pinch, the mean effort rating to turn the knob with a clockwise torque direction is 3.227 while the mean effort rating to turn the knob with a counterclockwise torque direction is 4.755. The preceding analyses show that the counterclockwise torque direction needs more effort than the clockwise torque direction to turn the knob.

The abovementioned analyses show that the effort to turn the knob with a clockwise torque direction is lesser than the effort to turn the knob with a counterclockwise torque direction. According to Seo, et al. [12], the torque is 22% greater for clockwise direction than for counterclockwise direction. So, applying clockwise torque direction requires lesser effort than the counterclockwise torque direction. Figure 2 shows the mean effort rating to turn samples 1(b), 2(b) and 3(b) which are in size 2. Sample 1(b) represents the big round knob, whereas samples 2(b) and 3(b) represent the big ball and star shaped knobs.

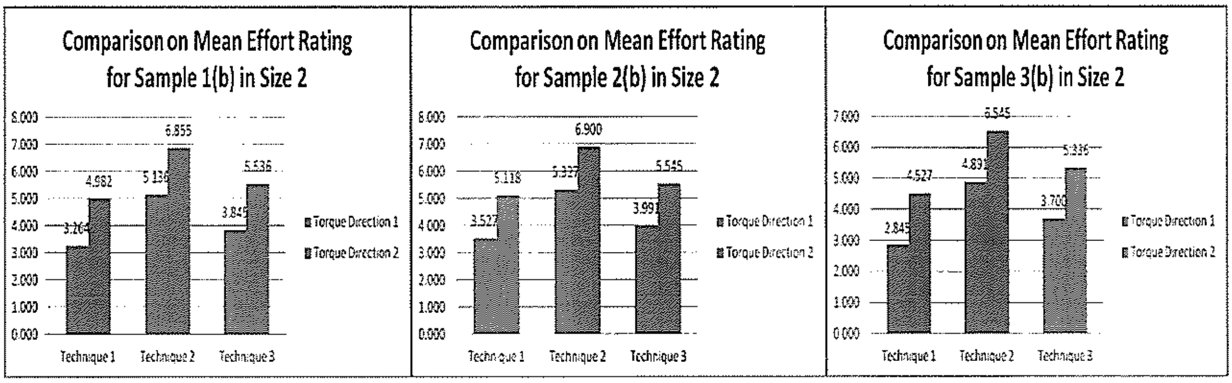

Figure 2: The Comparison on Mean Effort Rating for Size 2

Sample 1(b). Technique 1 which is the three jaw chuck pinch was used to turn the knob. The mean effort rating to turn the knob by using the three jaw chuck pinch with a clockwise torque direction is 3.264. While using pulp-2 pinch (Technique 2), the mean effort rating to turn the knob with a clockwise torque direction is 5.136 whereas the mean rating to turn the knob with a counterclockwise torque direction is 6.855. For Technique 3 which is the lateral pinch, the mean effort rating to turn the knob with a clockwise torque direction is 3.845 while the mean effort rating to turn the knob with a counterclockwise torque direction is 5.536.

Sample 2(b). Technique 1 which is the three jaw chuck pinch was used to turn the knob. The mean effort rating to turn the knob by using the three jaw chuck pinch with a clockwise torque direction is 3.527. Technique 2 which is the pulp-2 pinch produced a mean effort rating of 5.327 with a clockwise torque direction whereas the mean rating to turn the knob with a counterclockwise torque direction is 6.900. Technique 3 which is the lateral pinch produced a mean effort rating of 3.991 with a clockwise torque direction while the mean effort rating to turn the knob with a counterclockwise torque direction is 5.545. The analyses show that the counterclockwise torque direction uses more effort than the clockwise torque direction regardless of the techniques used.

Sample 3(b). Technique 1 which is the three jaw chuck pinch was used to turn the knob. The mean effort rating to turn the knob by using the three jaw chuck pinch with a clockwise torque direction is 2.845. Technique 2 which is the pulp-2 pinch produced a mean effort rating of 4.891 with a clockwise torque direction whereas the mean rating to turn the knob with a counterclockwise torque direction is 6.545. Technique 3 which is the lateral pinch produced a mean effort rating of 3.700 with a clockwise torque direction while the mean effort rating to turn the knob with a counterclockwise torque direction is 5.336. The analyses show that counterclockwise torque directions utilize more effort than clockwise directions regardless of the shapes and techniques.

Although the sizes are different, the effort to turn the knob with a counterclockwise torque direction is still greater than the effort with a clockwise torque direction. These findings are thus consistent with the findings from Seo, et al. [11], who state that clockwise torque can be used to exert greater forces compared to counterclockwise torque.

Conclusion

As far as the implications for theory and practice are concerned, understanding the effects of torque directions on pinch grips can be useful for industrial workers. With the consideration of the torque directions in pinching activities, guidelines can be developed to further improve hand tool designs and the capacity of torque exertions.

It should be generally made known to all manual workers somehow that the pinching objects with clockwise torque directions can exert greater forces compared to counterclockwise torque directions. Perhaps by knowing this information (through a safety guideline or procedure), workers will tend to change their manual working methods to accommodate the use of more clockwise rather than counterclockwise torque directions in their work. The extension of this research in the field of hand tool ergonomics is hoped to further reduce the possibilities of hand-related injuries.

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