Effects of the Different Screwdriver Handle Sizes on the Forearm Muscles Activities and Wrist Motion during Screw-driving Work

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Abstract. [Purpose] This study investigated the difference screwdriver handle size has on forearm muscle activities and wrist motion during screw-driving work. [Subjects] Fourteen males aged 20–30 years, were recruited. [Methods] We measured the forearm muscle activities using a MP 150 System and wrist motion using a 3D motion system. The subjects performed screw-driving tasks with different screwdriver handle sizes. [Results] The wrist flexion and ulnar deviation angles and flexor carpi ulnaris muscle activity significantly increased and wrist extension angle significantly decreased during screwdriver work with a thin handle. [Conclusion] We consider that industrial workers should perform screw-driving work using a screwdriver with a thick handle. 

Key words: Handle size, Screw-driving work, Wrist pain

INTRODUCTION

Work-related musculoskeletal disorders known as overuse injuries, account for a significant proportion of work injuries. There are several known risk factors for upper-extremity muscle injuries, including repetitive and continuous-flow assembly work. Work-related musculoskeletal disorders are a group of painful disorders of muscles, tendons, and nerves that can be induced by work activities that are frequent and repetitive, or that involve awkward postures. Carpal tunnel syndrome is a common and costly problem in the general population, especially among manual workers. Several studies have found a greater prevalence of carpal tunnel syndrome in workers who perform highly repetitive manual jobs. Manually rotating screw-driving tasks are often performed with highly repetitive wrist movements, and screw-driving may be a cause of carpal tunnel syndrome. Manual screw-driving also places high loads on the forearm muscles. In industry, operational efficiency has a strong influence on what tools are used and how the work is performed. Therefore, this study investigated the difference screwdriver handle size has on forearm muscle activities and wrist motion during screwdriver work.

SUBJECTS AND METHODS

Fourteen males, aged 20–30 years with a mean height and weight of 174.4 ± 6.5 cm and 65.1 ± 5.8 kg, respectively, participated in this study. The subjects had no history of musculoskeletal disorders or pain associated with the upper extremity in the past 6 months. EMG data were collected using a Biopac MP150WSW (Biopac System, Santa Barbara, CA, USA). The surface electrodes were attached parallel to each muscle fiber on the extensor carpi radialis and flexor carpi ulnaris on the right side. In order to normalize the EMG data, the maximum voluntary isometric contraction (MVIC) was determined for each subject. The angles of wrist flexion, extension, and ulnar deviation were obtained using a 3D motion analysis system (CMS-HS, Zebris Medizintechnik, Isny, Germany) with a sampling rate of 60 Hz. The angles were determined from the data of two triple markers placed by the same investigator at the dorsum of hand and forearm. The subjects performed 30 sets of screwdriver work within 3 minutes on a 1-m high table while standing. The screwdriver work consisted of one board on which 30 loose screws had to be driven home. The work was only to drive home the screws. We provided screwdrivers with a thin handle and a thick handle based on the same two screwdrivers. The thin handle had a diameter of 2 cm, and the thick handle had a diameter of 4 cm. The paired t-test of SPSS (Chicago, IL, USA) was used to analyze the significance of the differences in the forearm muscle activities and the wrist motion during between screw-driving work with the different-sized screwdriver handles. The alpha level for statistical significance was chosen as 0.05.

RESULTS

The wrist flexion angle was significantly increased during screwdriver work with the thin handle (12.6±8.6 degrees) compared to the thick handle (7.0±5.7 degrees). The wrist extension angle was significantly decreased during screwdriver work with the thin handle (11.2±5.1 degrees).
compared to the thick handle (19.4±10.5 degrees). The ulnar deviation angle was significantly increased during screwdriver work with the thin handle (15.9±10.1 degrees) compared to the thick handle (8.2±4.3 degrees). The flexor carpi ulnaris muscle activity was significantly increased during screwdriver work with the thin handle (42.0±14.9%) compared to the thick handle (33.7±12.4%). The extensor carpi radialis muscle activity showed no significant difference between screwdriver work with the thin handle (48.1±26.4%) and the thick handle (50.3±17.1%).

**DISCUSSION**

Manual and pistol-grip powered screwdrivers are the most commonly used tools, and screwdriver work is often performed with highly repetitive wrist movement. This study investigated the difference the size of a screwdriver handle on the forearm muscles and the wrist motion during screwdriver work. Stability of the wrist in high extension enables the finger flexor muscles to grip with force, and preventing the wrist from flexing is more conducive to higher grip force production. In the present study, the flexor carpi ulnaris muscle activity was significantly increased during screwdriver work with the thin handle, compared to the thick handle. When a strong grip is applied to an object, the wrist extensors hold the wrist in about 35 degrees of extension and about 5 degrees of ulnar deviation. This position facilitates maximal grip by optimizing the length-tension relationship of the extrinsic finger flexors.

When working using the screwdriver with the thin handle, the wrist flexion angle was significantly increased and the wrist extension angle was significantly decreased compared to working with the thick handle. Therefore, screw-driving work with a thin handle could cause instability in the wrist and prohibit maximal grip, because it prevents the wrist extensors from stabilizing the wrist. Also, manual and rotating screw-driving work requires ulnar deviation, and the work is often performed with highly repetitive wrist movement. When using a screwdriver with a thin handle, the ulnar deviation angle was significantly increased, so a screw-driving task performed with thin handle would cause wrist pain after highly repetitive screw-driving work. Therefore, we consider that industrial workers should perform screw-driving work using a screwdriver with a thick handle.

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