AN ELECTROMYOGRAPHIC AND PSYCHOPHYSICAL EXAMINATION OF FASTENER INITIATIONS IN AUTOMOTIVE ASSEMBLY

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INTRODUCTION

Injuries to the upper extremity region rank second among all reported occupational injuries [1]. Currently, limits are non-existent for low force, repetitive tasks such as Fastener Initiations (FI) performed in the automotive industry. The purpose of the current study was to determine acceptable human tolerance limits values (TLVs) for a fastener initiation task, which is commonly performed in the automotive industry.

METHODS

A psychophysical methodology was utilized to examine 24 non-skilled female subjects while performing fastener initiation tasks on a simulation device. The independent variables were: 1) wrist posture: neutral, flexion and extension, and 2) fastener size: large (10 mm depth, 20 mm diameter) and small (5 mm and 10 mm). For each condition, subjects were instructed to complete their maximal acceptable number of FIs over the course of a 60 minute trial. Subjects trained for 2 hours on each condition and were tested for 1 hour (total of 18 hours). The kinematic dependent variables were: 1) average number of 720 degree FIs per minute, 2) average duration of each FI and 3) average number of individual movements (efforts) per 720º FI.

Surface EMG was also used to monitor the muscle activity of forearm (biceps brachii (BB), brachioradialis (BR), flexor carpi ulnaris (FCU), extensor carpi ulnaris (ECU) and hand muscles (thenar (TR) and first dorsal interosseous (FDI)). A repeated measures ANOVA with Tukey's significance post hoc test were used to determine any significance within the measured variables ($p<0.05$).

RESULTS AND DISCUSSION

Both Posture and Fastener Size variables had significant main effects on all kinematic variables. Results indicated a 10% decrease in FIs per minute when the small fastener size was used, as well as a 10% increase in the average time to complete each FI when performing the task with the small compared to large fastener. In addition to the fastener size, posture was shown to have a significant effect on the kinematic data. Compared to the extended posture, the average number of FIs/min increased 12% and 7% for the neutral and flexed posture, respectively. In addition, the average duration of each FI was affected by posture with the extension being 12% greater than flexion and flexion being 8% greater than neutral.

The kinematic data used to determine the TLV showed interesting results as the large fastener/neutral wrist condition had the highest number of FIs (9.1±2.6), they were performed with the lowest number of efforts per FI and shortest duration per FI. TLVs were calculated as those acceptable to 75% of the female subjects (Figure 1). These ranged from 6.1 to 7.4/min depending on the fastener size and wrist posture.

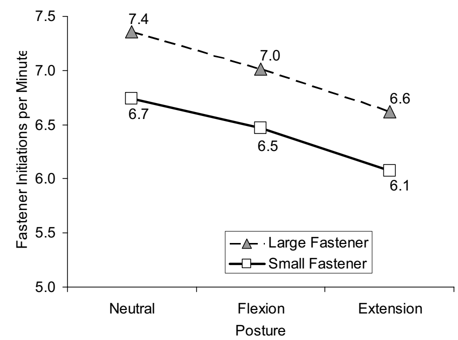

Figure 1: TLV for FI/minute calculated as the values acceptable to 75% of females (n = 24).

Electromyography data showed that posture, age and fastener size did, in certain instances, demonstrate significant interactions. In particular, posture had an effect on EMG from the BB, BR and TR muscles. The EMG of the BB was at its lowest (% of Maximal Voluntary Exertion (MVE)) during flexion and BR and TR were at their highest during extension. Interestingly, the ECU had the highest activity for all six conditions (mean of 13.5% MVE). This result parallels that of Mogk and Keir (2003), where the ECU higher activation is believed to be due to it role as a stabilizer to the internal and external moments about the wrist joint.

The kinematic and surface EMG data from this study show that both Posture and Fastener Size are important factors that affect the performance and acceptability of FIs. As the Posture variable deviated from neutral, and as the fastener became smaller, a significant decrease in the FIs per minute resulted. Thus, this study provides data to support the need for the design of more neutral hand-wrist human interfaces along with larger objects for the hand to manipulate. Such designs will potentially decrease the risk of musculoskeletal injury and/or increase productivity. Thus, this study has provided recommendations on acceptable human tolerances for the task of fastener initiations used in the manufacturing industry. Furthermore, EMG data provided valuable information regarding forearm and hand muscle activity during a low force, high frequency task.

REFERENCES

1. Workplace Safety and Insurance Board of Ontario's 2002 Annual Report.
2. Mogk, J. & Keir, P. *Ergonomics* **46**, 956-975, 2003

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