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Effect of Task Characteristics on Maximum Voluntary Contraction Recovery Time during a Lifting Task

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Abstract: Manual Material Handling can be defined as moving or handling loads by lifting, lowering, bending, twisting, holding, transporting, supporting, and other activities. Manual Material Handling (MMH) is one of the main causes of overexertion. According to the Bureau of Labor Statistics, 31.4% of all the injuries reported were due to overexertion in 2019. Overexertion leads to muscle fatigue and insufficient recovery time, which leads to work-related musculoskeletal disorders (WMSDs). To prevent overexertion during the MMH tasks, redesigning the tasks must include sufficient rest intervals between them. Task characteristics play a significant role in the redesign of the work. This study evaluates the effect of multiple task characteristics on the recovery time of the muscle. The task characteristics considered for the study are the weight of the lift, duration of lift, frequency of lift, distance of lift, and angle of lift. Two values of each variable, namely weight, duration, frequency, distance, and angle, are used in the experiment. Data were collected from 32 participants. The participants were assigned random lifting treatments. Maximum voluntary contraction (MVC) of the biceps muscles was measured before the start of the experiment, and 10 minutes of rest was provided for the participants to recover. The participants lifted the weights from knuckle height to the assigned treatment height. The MVC was measured after the treatment, and the time required to recover to 80% of the initial MVC value known as MVC recovery time (MVCRT) was calculated. An ANOVA test was used to find the factors having a significant impact on lifting task characteristics. Results indicated that the weight and duration of the lift had a significant impact on the recovery time. The angle of symmetry had the least impact on the recovery time. Weight and duration should determine the rest time required after a lifting task as they are significant among all the task characteristics. This study will help the managers to determine optimum rest intervals after a lifting task.

Keywords: Maximum Voluntary Contraction, Manual Material Handling, Lifting

1. Background and Objective

Work-related musculoskeletal disorders (WMSD) are a significant cause of concern in the industry. According to the World Health Organization, the leading causes of MSDs are long-term repetitive tasks, forceful exertions, sustained uncomfortable postures, and poor work practices (Luttmann et al., 2003). Overexertion due to long-term repetitive tasks is a main cause of injuries. The U.S. Bureau of Labor Statistics (2019) states that the number of injuries reported in 2018 due to overexertion and bodily reaction was 282,860, equivalent to 31.4% of all reported cases. In the same report, the incidence rate of overexertion was higher than injuries from other events or exposures. According to Anderson and Chun (2014), overexertion injuries are mainly caused by Manual material handling tasks. Recovery plays an essential role in avoiding the injuries caused by overexertion. The most favorable way of reducing injuries is redesigning the job or task. However, all jobs cannot be modified or altered from the perspective of manual labor (Whitfield et al., 2014). The worker's capability is also impacted by environmental factors, task characteristics, and rest intervals (Bangaru et al., 2019). Therefore, it is imperative to study the impact of the task characteristics on recovery time so the tasks can be modified to provide recovery time to prevent injuries.

Many studies were conducted to study the effects of the task characteristics on workers' capability (Abadi et al., 2015; Gallagher, 1991; Garg & Banaag, 1988; Maiti & Bagchi, 2006; Saavedra-Robinson et al., 2012; Wu, 1997). However, none of the studies have considered the localized fatigue of muscles to determine the effect of the task characteristics on the recovery time. This study aims to determine the effect of the task characteristics on recovery time using the maximum voluntary contraction recovery time (MVCRT) of the bicep muscles during a lifting task.

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2. Materials and Methods

A two factorial block design was used with five characteristics having two levels. The experiment was approved by the LSU IRB. The participants signed the consent form and were screened for any potential injuries before the experiment. The task characteristics used for the study are weight (8 and 12kg), duration (5 and 10 mins), frequency (6 and 12 lifts per min), distance (35 and 70 cm), and angle of symmetry (0 and 90). A combination of the task characteristics is used in the study. Thirty-two participants were used, with each participant conducting a single treatment. The mean age of the participants was 25, having an average BMI of 25.31.

EMG sensor was used on the biceps of the participants. The EMG signal was sampled at a frequency of 1000 hertz. The participants exerted five times at the start of the experiment. The peak value of these five readings was considered as the MVC of the participant. A rest interval of 10 minutes was given between the MVC activity and the start of the lifting protocol. The experimental protocol is given in Figure 1.

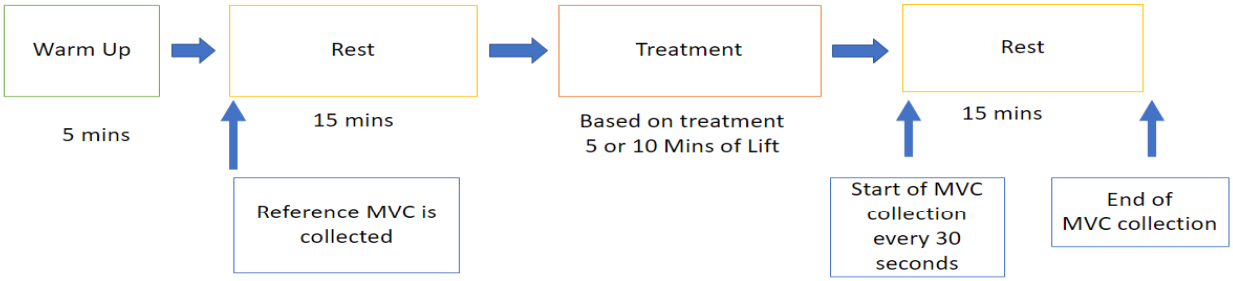

Figure 1. Experimental Protocol

The participants lifted a box with weights assigned based on the treatment from knuckle height to height assigned by the treatment. An application named Gymboss was used to set the pace of lifting according to the frequency. During the application the box was lowered to its original position by a helper so that the participants were only involved in lifting. Figure 2 illustrates a participant lifting from knuckle height to shoulder height.

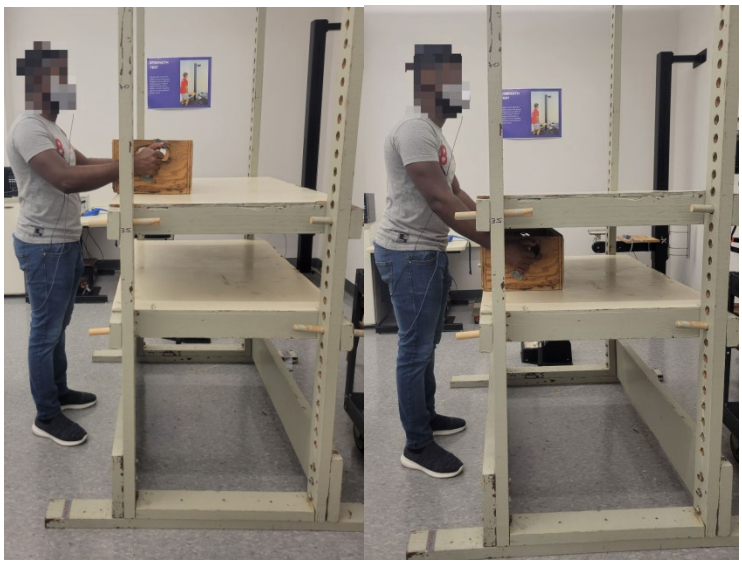

Figure 2. Participant performing a lift from knuckle height to assigned height

The participants performed the lifting followed by a single exertion in 30-second intervals for 15 minutes. Figure 3 illustrates a participant performing MVC of the biceps. The time taken by the exertion to reach 80% of the initial MVC value was considered as the recovery time based on earlier studies of Schwendner et al. (1995), Stull and Clarke (1971), and (Stokes et al., 1989).

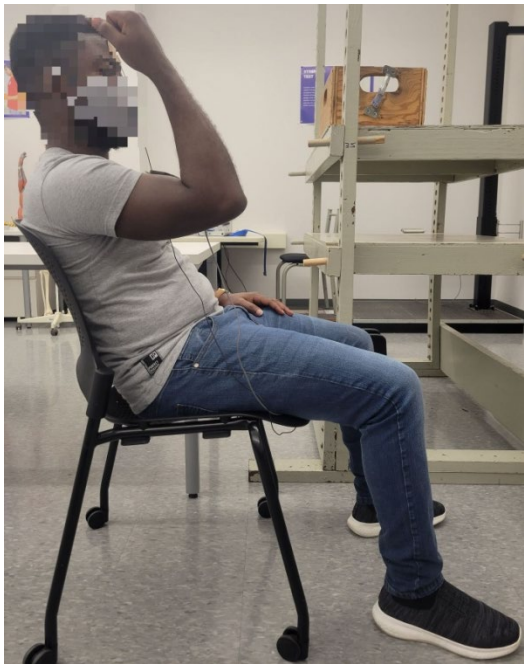

Figure 3. Participant performing MVC.

3. Results and Conclusions

An ANOVA test(p=0.05) was performed to determine the impact of each task characteristic on recovery time. The results of the ANOVA test are given in Table 1. Weight was found to have the most significant impact on the recovery times. Similarly, the duration of the lift had a significant impact on the recovery times between both levels. The angle of symmetry was found to have the least impact on the recovery time.

Table 1. p-values of the variables

Variable	p-value
Weight	0.0006*
Frequency	0.3331
Duration	0.0242*
Distance	0.8102
Angle	0.8102

There are some limitations to the study. The participants were only males. Future studies should include using females. Also, two levels of each of the task characteristics were studied. Studying more levels of the interactions will give a more detailed understanding of the factors' impact on recovery time. The effect of the interactions should be studied in the future. The study results can further identify the task characteristics having a significant impact on recovery time by managers and can be used to design the rest breaks in work tasks to avoid overexertion.

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