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Task Parameters Affecting Heart Rate Recovery Time for Repetitive Lifting

Research Article

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Abstract

Overexertion in physical activity leads to extreme fatigue, and having insufficient time for recovery could lead to work-related musculoskeletal disorders. To prevent injuries, tasks should be redesigned to include sufficient time for recovery. This study aims to evaluate the effect of lifting task parameters: duration of lift, weight of lift, distance of lift, frequency of lift, and angle of lift on the heart rate recovery time during repetitive lifting. The effect of these parameters was examined at two levels. Data was collected from 32 participants, and they were assigned random lifting tasks. The participant's heart rate was recorded for 15 minutes before the start of the experiment to determine the resting heart rate, and the initial time taken to sustain the resting heart rate for 2 minutes after the experiment was recorded as the heart rate recovery time. An ANOVA test was used to evaluate the task parameters that significantly impacted the heart rate recovery time. The results indicate that the duration of lift and the weight of lift significantly affected the heart rate recovery time, while the angle of lift had the least effect on the recovery time. This study helps supervisors to design an optimum work-rest cycle for workers.

Keywords: Heart Rate Recovery Time; Lifting Task Parameters; Work-Rest Cycle

Introduction

Work-related musculoskeletal disorders (WMSDs) are disorders of the muscles, joints, nerves, tendons, bones, cartilage, and ligaments caused by factors such as long-term repetitive tasks, forceful exertions, sustained uncomfortable postures, and poor work practice [1]. Worldwide, such countries as the United States, Britain, Japan, and Germany have these disorders listed as occupational diseases [2]. WMSDs are a leading cause of pain, disability, and suffering among workers. In addition to physical injuries, Loisel and Anema [3] stated that workers who have prolonged absences from work due to WMSDs suffer from psychological distress and disorder. Overexertion is one of the leading causes of WMSDs. In 2017, the cost of injuries due to overexertion accounted for about $13.98 billion, 23% of the total losses in the year [4]. The U.S. Bureau of Labor Statistics [5] stated that in 2018, the number of injuries reported due to overexertion was 282,860. This is equivalent to 31.4% of all injury cases reported. Overexertion injuries are mainly caused by manual material handling (MMH) tasks, which usually require substantial effort [6]. MMH is the handling or moving loads by lifting, bending, lowering, twisting, transporting, holding, supporting, and other daily activities, whether once or regularly, using human energy and forces [7]. Human physical input is needed to perform MMH tasks, and workers performing MMH activities have a higher risk of WMSDs. The consequence of overexertion in physical activity is extreme fatigue. Janaro and Bechtold [8] stated that workplace fatigue can affect workers' productivity and physical capacity, leading to increase in number of work errors and workplace injuries. If the fatigue exceeds a certain level, it would lead to severe injuries [9]. Therefore, it is essential to rest appropriately for fatigue recovery. Research shows that heart rate is a reliable parameter to study generalized fatigue and recovery [10-13].

Several studies investigated the effects of lifting task parameters, namely, load weight [14], lifting frequency [10,15], symmetry angle [12], lifting posture [11], and lifting distance [10,14] on heart rate. A study also investigated the effect of three task parameters: weight, frequency, and distance of lift on heart rate recovery time [16]. However, no study has examined the effect of five lifting task parameters on heart rate recovery time. This study aims to determine the impact of the five task parameters: duration, weight, frequency, distance, and symmetry angle of lift on heart rate recovery time for a repetitive lifting task.

Methodology

A two-factorial block design was used for this study. The design includes five lifting task parameters with two levels each. The task parameters are duration (5 and 10 minutes), weight (8 and 12kg), distance (35 and 70cm), frequency (6 and 12 lifts per minute), and angle of symmetry (0 and 90). Thirty-two treatments were used for this study, comprising a combination of these task parameters. Thirty-two participants were recruited for this study, each assigned to a single treatment combination. The mean age of the participants was 25 years, with an average BMI of 25.31. The polar heart rate monitor H7 and Fit IV application [Figure 1] were used to record heart rate data. Figure 2 shows the experimental protocol.

Figure 1: Polar Heart Rate Monitor and Fit IV Application.

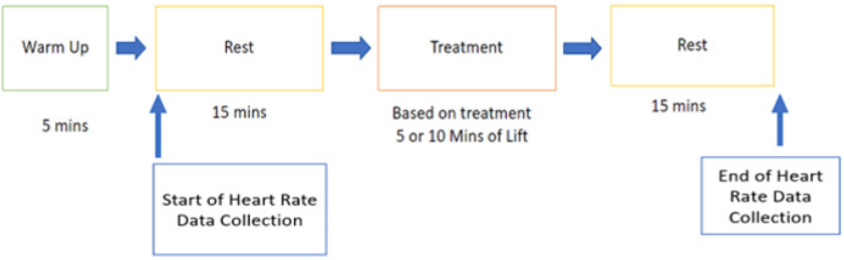

Figure 2: Experimental Protocol.

The heart rate monitor was placed on the participants' sternum, and the heart rate was recorded for 15 minutes before the start of the experiment to determine the resting heart rate. The participants then lifted a box with the weight assigned based on the treatment combination from the knuckle height to the assigned treatment distance. A helper lowered the box to its original position, so the participants were only involved in the lifting task. The Gymboss application software was used to control the lifting frequency. After the lifting task, the participant was guided to rest and be seated while the heart rate was monitored. The time taken for the heart rate to recover to its pre-task steady stage was recorded as the recovery time. The steady stage is where the heart rate fluctuates within the 10% range for 2 minutes [16]. Figure 3 shows a participant lifting from knuckle height to an assigned treatment height.

Figure 3: Participant Lifting Task.

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Results

The mean and standard deviation of heart rate recovery time for the 8 kg was 121 (29.8) seconds, while the mean and standing deviation of recovery time for the 12kg was 161 (30.7) seconds. From the results, the mean value of the recovery time increased as the weight increased, having a percentage change of 33%. The mean and standing deviation of recovery time value for the 5-minute lifting duration was 127 (32.7) seconds. The mean and standing deviation value of recovery time for the 10-minute lifting duration was higher than the 5-minute duration at 155 (34.9) seconds, having a percentage change of 22%. The two levels of lifting distance were 35cm and 70cm. The mean and standing deviation values of recovery time for the 35cm and 70cm were 137 (42.1) seconds and 146 (30) seconds, respectively. The mean heart rate recovery time value slightly increased with increased lifting distance. The percentage change was 6%. The mean and standing deviation of recovery time values for the 6 lifts per minute and 12 lifts per minute were 136 (32) seconds and 146 (40.5), having a percentage change of 7%. The mean values of the recovery time for both angles of symmetry were 141 seconds. The standard deviation (39.6) of the 90-degree or asymmetric lifting was higher than the standard deviation (33.8) of the 0-degree or symmetric lifting. The changes in slopes of the different task parameters and their percentage changes are shown in Figures 4 and Figure 5, respectively. The weight and duration had higher slopes than the other task parameters.

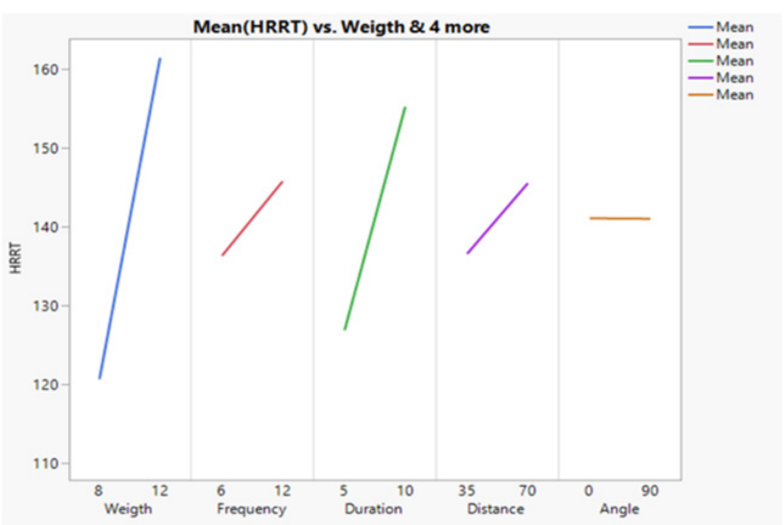

Figure 4: Means of Heart Rate Recovery Time vs. Task Parameters.

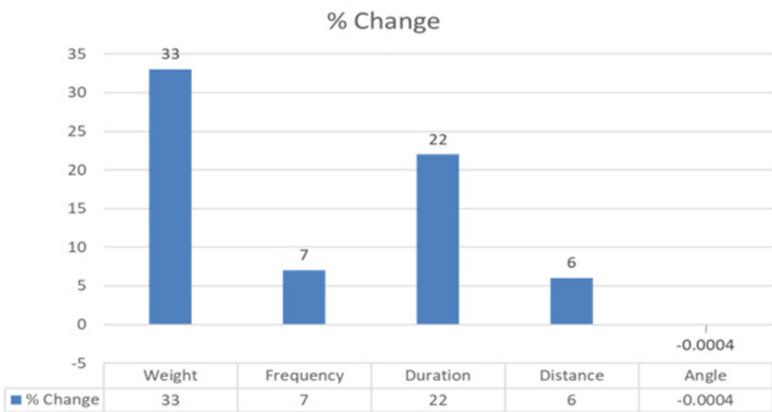

Figure 5: Percentage Change of Mean Heart Rate Recovery Time for Task Parameters.

An ANOVA test (p=0.05) was conducted to examine the effect of each task parameter on the heart rate recovery time. The results of the ANOVA test are shown in Table 1. The weight was found to have the most significant effect on the heart rate recovery time. Similarly, the duration of lift also had a significant effect on the recovery time. The angle of symmetry had the least impact on the recovery time.

Table 1: P-Values of the Variables.

Variable	p-value
Weight	0.002*
Frequency	0.28
Duration	0.0101*
Distance	0.28
Angle	0.98

*Indicates significant variables.

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Discussion

The heart rate recovery time increased for all the lifting task parameters from the lower end to the higher end, except for the angle of symmetry. The weight of lift had the highest increase in the heart rate recovery time, followed by the duration of lift. The percentage increases for the weight and duration of lift were 33% and 22%, respectively. The result of this study on the weight of lift was consistent with the results by Aghazadeh and Amini [16], reporting that an increase in weight leads to an increase in the heart rate recovery time. There was also an increase in the recovery time for frequency (7%) and distance (6%), although it was insignificant. There was no change in the recovery time for the angle of symmetry. The results of the ANOVA test show that the weight of lift and duration of lift significantly impacted the recovery time for the heart rate. In contrast, the frequency of lift, distance of lift, and angle of symmetry were not significant.

There are some limitations to this study. First, the experiment was conducted in a controlled laboratory. A real-world scenario in a workplace might produce a different result due to impacts from varying factors. Another limitation is the small sample size. A larger sample size would give more accurate results. In addition, the participants were college students with little or no work experience. Finally, the study included only male participants. Future studies could include female participation.

Conclusion

In conclusion, this study found that weight and duration of lift significantly affect heart rate recovery time. Increases in weight and duration led to 33% and 22% increases in recovery time, respectively. These findings highlight the need to consider weight and duration in designing rest intervals to prevent work-related musculoskeletal disorders (WMSDs). This study's outcome will help supervisors design an optimum rest interval for workers' recovery. However, further research in real-world conditions with a larger, diverse sample is needed to validate these results.

References

1. Atlas AP, Bondoc R, Garrovillas R, Lo RD, Recinto J, et al. (2007) Prevalence of low back pain among public high school teachers in the City of Manila. Philippine Journal of Allied Health Sciences 2(1): 34-40.
2. Shuai J, Yue P, Li L, Liu F, Wang S (2014) Assessing the effects of an educational program for the prevention of work-related musculoskeletal disorders among school teachers. BMC public health 14: 1211.
3. Loisel P, Anema JR (2013) Handbook of work disability. Prevention and management.
4. Liberty Mutual Insurance (2020) 2020 workplace safety index: the top 10 causes of disabling injuries.
5. (2019) US Bureau of Labor Statistics Employer-Reported Workplace Injuries and Illnesses (Annual) News Release US Bureau of Labor Statistics.
6. Anderson VP, Chun H (2014) Workplace hazards and prevention options from a nonrandom sample of retail trade businesses. International journal of occupational safety and ergonomics 20(1): 181-195.
7. Kamarudin NHB (2019) Development of Predictive Model for Stoop and Squat Postures on Physiological and Psychophysical Responses In Manual Lifting Tasks. Universiti Putra Malaysia.
8. Janaro RE, Bechtold SE (1985) A study of the reduction of fatigue impact on productivity through optimal rest break scheduling. Human Factors 27(4): 459-466.
9. Chowdhury RH, Reaz M, Ali M (2014) Determination of muscle fatigue in SEMG signal using empirical mode decomposition. 2014 IEEE Conference on Biomedical Engineering and Sciences (IECBES).
10. Abadi ASS, Mazlomi A, Saraji GN, Zeraati H, Hadian MR et al. (2015) Effects of box size, frequency of lifting, and height of lift on maximum acceptable weight of lift and heart rate for male university students in Iran. Electronic physician 7(6): 1365-1371.
11. Gallagher S (1991) Acceptable weights and physiological costs of performing combined manual handling tasks in restricted postures. Ergonomics 34(7): 939-952.
12. Garg A, Banaag J (1988) Maximum acceptable weights, heart rates and RPEs for one hour's repetitive asymmetric lifting. Ergonomics 31(1):77-96.
13. Pusapati VK V, Imuetinyan D, Aghazadeh F (2023) Regression Modeling of Rest Intervals using Heart Rate Recovery Time for a Lifting Task using Task Variables. IISE Annual Conference and Expo.
14. Maiti R, Bagchi TP (2006) Effect of different multipliers and their interactions during manual lifting operations. International Journal of Industrial Ergonomics 36(11): 991-1004.
15. Wu SP (1997) Maximum acceptable weight of lift by Chinese experienced male manual handlers. Applied ergonomics 28(4): 237-244.
16. Aghazadeh F, Amini M (2017) Effect of task factors on the heart rate recovery time in a lifting task. Occupational Ergonomics 13(S1): 71-80.

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