EFFECT OF WORK REST SCHEDULE ON PERCEIVED DISCOMFORT SCORE AND THERMAL THRESHOLD SHIFT OF OPERATORS USING HAND-HELD VIBRATING MACHINES

Jagvir Singh, Abid Ali Khan, and Mohammad Muzammil*
Ergonomics Research Division, Department of Mechanical Engineering, Aligarh Muslim University, Aligarh, India
*Corresponding Authors's Email: mmuzammil18@yahoo.co.in

1. INTRODUCTION

Time-integrated fatigue may lead to different types of injuries during the operation of a machine (Muller, 1953; Folkard and Monk, 1985; Rosa, 1995; Christensen et al., 2000). Such fatigue stretched over a period of months and years may cause physical, physiological and musculoskeletal disorders (Waersted and Westgaard, 1991). In many real working tasks in industrial settings, the periods of intense physical activity alternate with rest periods or periods of lighter work. This maximizes the total quantity of physical work an individual can perform during the working day, compared to working at a steady but lower level (Muller, 1953; Astrand, 1960). In such cases, the work is designed so that the overall energy expenditure, averaged over the working day and taking into account both work and rest, remains within acceptable limits.

According to different classifications, the health effects of hand-arm vibration (HAV) have vascular, neurological and musculoskeletal system components (Griffin, 1990; Mason and Poole, 2004). Vascular disorders are characterized by attacks of cold-induced finger blanching, and are the most extensively studied symptom of hand-arm vibration syndrome (HAVS).

A dose–response relationship has been established between exposure to HAV and the risk of vibration induced white fingers (VWFs) on the basis of several epidemiological studies (Gemne and Lundström, 1996; Bovenzi, 1998). The occurrence of HAVS may be predicted on the basis of cumulative exposure to HAV according to the international standard ISO 5349.

Because of the viscoelastic, time-dependent behaviour of biological tissues, even low intensity loads (such as during drilling operations) applied for longer durations may increase the chances of tissue damage (Goldstein et al., 1987; van Dieën and Toussaint, 1995; van Dieën and Oude Vrielink, 1998). Work-rest schedules allow for more variation and periodic recovery from the stress of the work (van Dieën and Oude Vrielink, 1998).

Thus, under such situation, the administration of suitable work-rest schedules seems to be a feasible approach to reduce the time-integrated (cumulative) workload on the operator, and potential for tissue injury.

The major aim of the study was to identify a work-rest schedule for optimum work output in a hypothetical drilling operation, by assessing operator discomfort and thermal threshold shifts in the fingertips under conditions of variable work-rest conditions.

2. METHOD

The subjects were asked to stand at a fixed position on the floor with respect to the drill rig, which was prepared in the workshop of a mechanical engineering department. The subject was asked to keep the elbow flexed at 90^0, the forearm horizontal and upper arm in vertical position, in the coronal plane. Prior to the start of the actual drilling task, the subjects rehearsed the drilling operation to become familiarized. Five different conditions were defined: A1 (work- 01 minute; rest- 03 minutes), A2 (work- 01.5 minutes; rest- 02.5 minutes), A3 (work- 2 minutes; rest- 02 minutes), A4 (work- 2.5 minutes; rest- 1.5 minutes) and A5 (work- 3 minutes; rest- 1 minute).

Participants worked for 20 minutes on the drilling task, keeping the feed force constant at 60N (±3N). A rest period of 20 minutes was provided to each participant after each series of five conditions, in order to recover from fatigue. The subject performed the different conditions in a random order. At the end of each condition, a perceived discomfort score was recorded on visual analog scale. The Visual Analogue Scale was labeled as: 0 for 'no discomfort'; 5 for 'moderate discomfort' and 10 for 'extreme discomfort'.

The Thermal Threshold Shift (TTS) was measured using a device consisting of a heating plate and a thermocouple for recording the temperature instantly. The subject was asked to keep the fleshy part of the right index finger tip over the centre of a metal plate which was slowly heated. The subject was also asked to report immediately when a change in temperature was sensed, by pressing an alarm button. The TTS (in ^{0}C) was the difference in temperatures of the plate, before and after the tasks when the subject sensed a change in temperature.

3. RESULTS AND DISCUSSION

The results of the study showed similar patterns for perceived discomfort score and TTS (Figures 1 and 2). The condition - A1 showed the least discomfort and lowest

TTS while condition - A4 resulted in highest discomfort and highest TTS.

To understand the effect of order, mean values of discomfort level for all combinations performed at various order were calculated, and a graph of order of the experiment and Mean Discomfort score for different job schedules was plotted (Figure 3). From the graph, it is evident that the discomfort score of participants increased with order of the experiment. It appeared from the graph that the rest duration of 20 minutes was not sufficient to recover fully and perform the next work as if there was no effect of previous work.

Figure 1. Variation of mean discomfort score with work condition (varying work time: rest time).

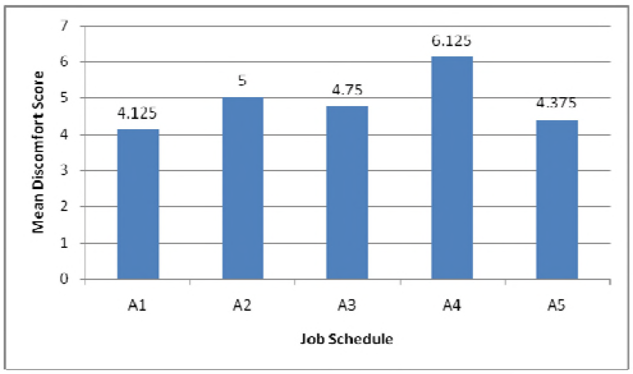


Figure 2. Variation of Thermal TTS with condition (varying work time: rest time).

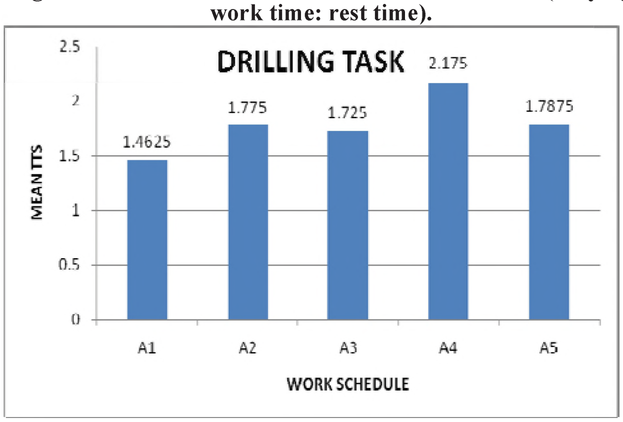
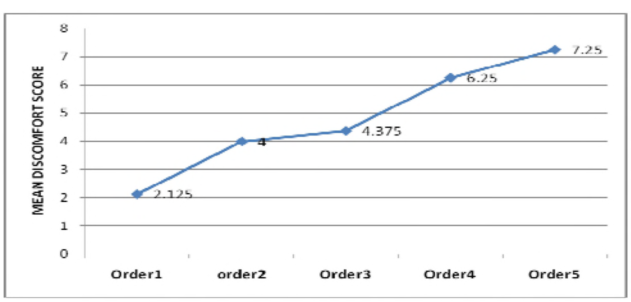


Figure 3. Effect of order of experiment on mean discomfort score for different job schedules.



4. CONCLUSIONS

- Thermal TTS and perceived discomfort score were observed to be similar in nature.
- A low level of discomfort and thermal TTS were observed when the drilling task was performed for one minute duration with a rest period of three minutes.

REFERENCES

Astrand, I., (1960). "Aerobic work capacity in men and women with special reference to age," Acta Physiologica Scandinavica **49** (suppl.), 169.

Bovenzi, M., (1998). "Exposure-response relationship in the hand arm vibration syndrome: an overview of current epidemiology research," Int. Arch. Occup. Environ. Health, **71**, 509–19.

Christensen, E. H., Sjøgaard, K., Pilegaard, M., and Olsen, H. B. (2000). "The importance of the work/rest pattern as a risk factor in repetitive monotonous work," Int. J. Ind. Ergon., **25**, 367–373.

Folkard, S., and Monk, T.H. (eds.) (1985). "Hours of Work: Temporal Factors in Work-Scheduling," in: *Psychology and Productivity at Work Series* (Wiley, New York).

Gemne, G., and Lundström, R., (1996). "Evaluation of the white finger risk prediction model in ISO 5349 suggests need for prospective studies," Cent. Eur. J. Public Health, **4**, 137–9.

Goldstein, S.A., Armstrong, T.J., Chaffin, D.B., and Matthews, L.S., (1987). "Analysis of cumulative strain in tendons and tendon sheaths," J. Biomechanics, **20**, 1–6.

Griffin, M.J. (1990). *Handbook of Human Vibration* (Academic Press, London), pp. 553–608.

Mason, H., and Poole, K., (2004). *Evidence Review on the Clinical Testing and Management of Individuals Exposed to Hand Transmitted Vibration* (Faculty of Occupational Medicine of the Royal College of Physicians, London), pp. 13–6

Muller, E.A., (1953). "Physiological basis of rest pauses in heavy work," Quarterly J. Exp. Physiology**, 38**, 205–215.

Rosa, R.R., (1995). "Extended work shifts and excessive fatigue," J. Sleep Research**, 4**: 51–56.

van Dieën, J. H., and Oude Vrielink, H. H. E. (1998). "Evaluation of work-rest schedules with respect to the effects of postural workload in standing work," Ergonomics ,**41**, 1832–1844.

van Dieën, J. H., Toussaint, H. M. (1995). "Application of the maximum energy criterion to describe the strength of the motion segment under axial compression," Spine **20**, 518–525.

Waersted, M., Westgaard, R. H., (1991). "Working hours as a risk factor in the development of musculoskeletal complaints," Ergonomics, **34**, 265–276.

ACKNOWLEDGEMENTS

This work was supported by the grant of All India Council of Technical Education (AICTE, New Delhi) Reference No. F/No 8023/BOR/RID/RPS-23/2008-09.