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The Investigation Of An OptimalWork-Rest Schedule Fof Vdt Operators

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ABSTRACT: *This study investigated the work-rest schedules for VDU users to minimize the task fatigue stresses. It was hypothesized that it would be significant differences in work performance and fatigue levels be detected among young and old VDU operators for schedules of 1) one-minute break from computer work every fifteen minutes of work; 2) three-minute break from the computer work every half an hour at the keyboard, and 3) five-minute break every an hour work. The study conducted using compare work task tested on ten VDU subjects for three months for each schedule. Work performances were measured in terms of percentage of correct detection, signal working time, and daily change in physical and psychological fatigue in terms of heart rates and discomfort rating. The 15 min work/1 min rest schedule resulted in significantly lower discomfort ratings and heart rates and the highest speed, accuracy, and performance for both age groups, compared with the 60/5 and 30/3 schedules. In addition, young subjects were faster reacted than the old subjects in search and reaching tasks. The study concluded that short time pauses in periodical periods has a good impact on the job performance and for employers health.*

KEYWORDS: *Work–rest schedule; Visual display terminal; Cumulative trauma disorder; Productivity; Data entry task*

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I. INTRODUCTION

Numerous people use computers regularly. In 1980, the United States had 13 million computers in operation. By 1990, the figure had risen to 40 million (Nevala-Puranen, 2003). Nowadays, there are over 2 billion computer users worldwide (Statista, 2019). Not surprisingly, the increased use of computers has increased operator stress issues associated with video display units (VDUs) (Filon et al., 2019). According to a study cited by Dimate and others (2017) and published in the journal Health and Safety Executive (2015), musculoskeletal disorders (MSDs) increased from 141,000 cases in 2012 to 184,000 cases in 2013 in the United Kingdom. Additionally, MSDs account for most work-related health-related absences (9.9 million days), accompanied by stress, depression, or anxiety (9.5 million days). Similarly, MSDs pay for nearly 70 million doctor visits and 130 million dollars in the United States for medical care expenses (National Research Council; Institute of Medicine, 2001). Tenosynovitis, carpal tunnel syndrome (CTS), tendinitis, and epicondylitis are among these conditions. Every year, nearly 2 million jobs in the United States suffer from CTS and tendinitis [SHRM, 2014]. Per year, 600,000 employees take time off work to recover from and treat CTS [Los Angeles Times, 2001]. According to a 2003 U.S. Bureau of Labor Statistics' survey, the age group of 35 years and older accounts for 77.5 percent of CTS cases [NIOSH, 2004]. Feng et al. (2021) showed that prolonged computer use time and working without breaks were associated with presence of wrist/hand symptoms. Cumulative trauma disorders are currently known to be the most expensive and severe disorders that arise in office work environments.

When typing, there are four major risk factors for developing cumulative trauma disorders: force, static exertion, repetition, and awkward posture. Additionally, prolonged typing can cause fatigue, increasing the amount of muscle activity needed to generate a given level of force (Cheng et al., 2019). Concern for finger forces stems from the fact that they contribute to chronic muscle, tendon, and nerve disorders. While the mechanisms underlying these conditions are unknown, they are believed to include mechanical and physiological processes. Automated processes are those that cause tissues to deform. Deformation is composed of two components: elastic and viscous. Elastic deformation occurs instantaneously in response to the applied force. Viscous deformation happens over time due to prolonged work or repetitive exertions with inadequate recovery time between successive efforts. Since soft tissues are viscoelastic, they can be influenced by both force and repetition. It is therefore critical to investigate the factors that bring relief to the hands' person.

Additionally, a recent paper from the Dimate-Garcia and Rodríguez-Romero study (2021) observed a steady accumulation of eye and musculoskeletal strain among video display terminal (VDT) staff that cannot be removed by using high-quality workstations. These types of findings have triggered calls for a restriction on the length of time spent doing continuous VDT work (Sa et al., 2012). They assert that each human body role can be viewed as a rhythmic balance of energy intake and replacement, or in a more straightforward manner, as a balance of work and rest. This dual process is essential for the muscles and heart to function correctly.

Additionally, rest pauses are a physiological necessity for success when considering all biological functions with work efficiency should be preserved. Rest breaks are critical not only during manual labor but also during work that places a strain on the nervous system, whether through the requirement of manual dexterity or the need to track a large number of incoming sensory signals. The U.S. Department of Labor Occupational Safety and Health Administration (OSHA) (1997) recommends that a 15-minute rest break be taken at least every two hours for moderately demanding tasks and a 10-minute rest break every hour for intensive activities performed at a VDT. Similarly, a 5-minute rest break every hour is recommended for intensive VDT work (e.g., continuous keyboarding uninterrupted by other activities). However, rest breaks taken too frequently can disrupt work rhythms and decrease productivity levels (Rohmert, 1973; Aitken, 1994).

Work studies have shown that people at work take rest pauses of various kinds and under varying circumstances. Four pauses types can be distinguished: spontaneous pauses, disguised pauses (i.e., switching to the routine job for a time), pauses arising from the nature of work, and prescribed pauses (i.e., laid down by the management). The noticeable pauses for rest, the staff takes on their initiative, are known as spontaneous pauses. Typically, they are not very long. However, if the work is physically demanding, it can occur often. Work-conditioned pauses are any interruptions caused by the machine's operation or the way the work is organized. Such pauses are waiting for the machine to complete a phase in its operation, such as a tool to cool down, a piece of equipment to warm up, a part to arrive, or a machine or tool to be repaired. Waiting periods are regular in the service sector, for example, when customers or orders are awaited. The length of work-related pauses is dictated by the operative's speed and dexterity on a conveyor belt. The faster he or she works, the longer the following piece takes to arrive. Prescribed breaks are work breaks that supervisors specify, such as the midday break and other snack breaks, such as a coffee break.

The differing views on the influence of working hours on the adverse effects of VDT work are contentious. Although some observed a rise in complaints as working time at a VDT increased (Kopardekar and Mital, 1994; Galinsky, 2000), others could not confirm this relationship (Henning et al., 1997; Galinsky, 2000; McLean et al., 2001). Certain unions and a few scientists have argued that the number of hours spent per day at VDTs should be decreased (Aitken, 1994). Some studies found no significant differences in mood states between self-initiated and computer-enforced rest breaks (Henning et al., 1994; Galinsky, 2000). A fundamental point must be made here: neither time adjustment nor time reduction should be considered before the monitor, workstation, and atmosphere complies with the primary ergonomic design guideline. It would be absurd to shorten working hours as a result of poor workplace design. There are compelling reasons to conclude that work at an ergonomically sound VDT workstation is no more strenuous than other office tasks. Certain unions advocate for hourly rest periods for VDT operators. Such plans could be considered for highly repetitive and time-sensitive data entry tasks. However, the majority of VDT workers are unquestionably equivalent to traditional office jobs. For which two pauses for rest are given. One morning shift and one afternoon shift are recommended.

Based on the previous discussion, it can be concluded that no specific rest breaks are well-known as effective in reducing fatigue and increasing productivity during VDT work. Therefore, this study aimed to determine the best rest pauses in terms of frequencies and durations. Furthermore, the frequency and duration of rest breaks should consider the nature of the task and the worker's perception of fatigue and productivity.

II. METHODOLOGY

II.1. Subjects

Five students (aged between 19 and 23 years) were unpaid volunteers, and five old male subjects (aged between 41 and 55 years) who unpaid volunteers, except two of them were rewarded, were served as subjects in this experiment. All subjects are normal or fully corrected vision. In addition, all are right-handed.

II.2. Apparatus

The instruments used to perform this project are electrocardiography (ECG), micro-computer, CRT display monitor, keyboard as response station, and software programs written in a Microsoft Visual Basic language (version 5.0). Luminous white characters have appeared against a dark black background (i.e., the display contrast was positive). English letters were randomly generated and displayed in the middle of the monitor. A keyboard key is considered a response station. The application of pressure to the last entry digit in the set will activate the clock mechanism to stop and compute and record the response time and error rate. A modified scale of discomfort was presented to the subject in a sheet of paper after the subject executed the trials of the assigned treatment.

II.3. Experimental Design and Procedures

The two different groups of subjects were performed this visual task. Each assigned group of subjects (e.g., five subjects) was performed one task. Compare task is considered as one type of the primitive cognitive tasks that are defined and illustrated in different taxonomies. These tasks are reported in the process control literature as part of the jobs of human operators, although these tasks are varied in complexities. The cognitive task that is tested is described and illustrated in Table 1.

Table 1. Description and illustration of the cognitive task employed in the study

Compare task
View the first reference symbol, then the field symbol in the adjacent position for a correspondence test. If the test fails, response no; otherwise, moves to the sequential position and continues to the last symbol test succeeds. Hence, response yes. Example: Are the strings identical? Q R B N K J S D I P X Z M A Q R B N K I S D I P X Z M A * Symbol used (letters). * Reference - Only one character. * Field size (14 characters). * Congestion - Blank Spaces Between (one column and two rows)

Each character is 8 mm wide by 10 mm high and is viewed from about 50 cm. Again, the subject task is to push an appropriate button in the response station as quickly as possible while keeping accuracy as high as possible. The difficulties of the task are complex responses. In other words, in a simple task, the subjects could be asked to press the button corresponding to the simple set that appeared on the screen. In a complex response task, however, the subjects are asked to push the button that corresponds to the stimulus number.

Each subject was exposed to one of the three different sets of rest pauses. They are 1) one-minute break from computer work, every fifteen minutes of work; 2) three-minute break from the computer work every half an hour at the keyboard; and 3) five-minute break every an hour work. Each session lasted for 2 hours of work at the keyboard.

Each subject performed all treatment pauses within the assigned task. The subjects were received one training day followed by test days. On the first day, subjects practiced sessions. During the training session, the subjects were given their feedback performances to teach them to keep their performances as high as possible. On the test days, subjects were constructed to refrain from consuming any food or coffee at least three hours prior to their scheduled session. The actual experiment was started with a pre-work rest period where the subject was seated, so his physiological parameters stabilized. The subject performed each treatment in a randomized order.

Continuous signals were presented for each test treatment. The subject permitted 3000 ms to respond to a signal after it is presented. If the subject failed to respond within this period, his score was calculated as a miss. The subject would also be instructed by the experimenter not to press the buttons more than once because the program only accepts the first given. The maximum time between stimuli was 3000 ms. In addition, the time between different treatment sessions was at least a couple of days.

At the end of each treatment session, subjects rated each work on a modified General Discomfort Rating Scale that is implemented. A seven-point discomfort scale in which a score of 1, 3, 5, and 7 corresponded to completely comfortable, quite comfortable, just noticeable discomfort, and completely discomfort, respectively, will be implemented in this study. It was felt that the modified General Discomfort Rating Scale would provide finer discrimination than that obtained by having subjects choose a number between one and seven and recording that number in a sheet. Instead, the subject placed an * on a line of 7 cm long to express his feeling of discomfort.

Two factorial-repeated measures design was employed for all dependent variables. The form of this experiment was A X (B X S). Factors A, B, and S are expressed as age group (young vs. old subjects), rest-pause conditions (e.g., one/15, 3/30, and 5/60 rest/work ratios), and the subject variable, respectively. The dependent variables are cardiac cost, reaction time per character, accuracy in percent, and discomfort rating.

III. RESULTS

The average of the data at the end of the working hours was considered for the data analysis. All analyses of variances (ANOVAs) were performed on the data in the form of a two-way within-subject factorial design using the statistical package for social sciences (SPSS/PC+ software, version 20). In a case of significant of main variables and a significance of their level of interaction, only a higher level of interaction was analyzed, neglecting to analyze their main effects. The mean values of the dependent variables are grouped, as shown in Table 2. Table 2 shows the different values among young and old subjects as well as pauses work-rest ratios.

Table 2. Means and (Standard deviation) of all dependent variables considered in this experiment.

Parameters	Signal Response Time (Sec.)	Percentage of Correct Responses	Heart rates (beats/min.)	Discomfort Ratings
Mean values for Young subjects	6.42(2.31)	88.78(4.77)	88.13(11.08)	3.93(1.25)
Mean values for Old subjects	7.59(2.07)	86.25(7.48)	76.63(6.40)	4.27(1.45)
Mean values for 15/1 schedule	6.37(1.35)	90.71(2.81)	75.79(7.11)	2.91(0.43)
Mean values for 30/3 schedule	7.15(2.56)	87.94(3.62)	81.20 (7.57)	3.68(0.44)
Mean values for 60/5 schedule	7.50(2.66)	83.90(9.47)	90.15(13.05)	5.70(0.93)

III.1. Signal response time

None of the main variables had significant effects on human performance. Only age by work-rest periods interaction was significant, F (2, 16) =3.65, p<0.049. Therefore, separate ANOVA was performed using the simple effect technique Keppel (1984) to assess the effect of age by work-rest interaction time. As shown in Figure 1, at the level of 15-minute work/one-minute rest, the young subjects reacted not significantly different from the old subjects' performances; however, at 30 minute-work/3 minute rest, the young subjects responded significantly faster than old subjects did, F(1,16)=8.72, p<0.009. The same result was obtained for the third work-rest period, F(1,16)=9.31, p<0.008.

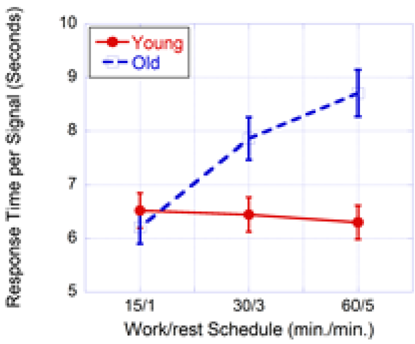

Figure 1. The effect of age by work/rest schedule interaction on signal response time.

III.2. Heart rates

Only work/rest schedule was significant, F (2, 16) =3.65, p<0.049. Duncan test had been employed between the means of work-rest levels. As shown in Fig. 2, the subjects performed significantly with less effort at 15 min woke/1min rest compared to 30 min/ 3 min rest. Also, the subject performed significantly with less effort at 15 min woke/1 min rest compared to 60 min work/5 min rest. In addition, the subject performed significantly with less effort at 30 min/3 min rest compare to 60 min work/5 min rest.

Figure 2. Effect of work/rest schedule on the heart rates.

III.3. Total response time

To assess the effects of independent variables on task performance, ANOVA was performed with total time response as the third dependent variable. None of the main variables nor interaction had significant effects on human performance.

III.4. Percentage of correct responses

Only work rest had a significantly different, F (2, 16) =4.99, p<0.021. Duncan test had been employed between the means of work-rest levels. As shown in Fig. 3, the subjects performed significantly well at 15min work/1min rest compared to 30 min/3 min rest. Also, the subject performed significantly well at 15min work/1 min rest compared to 60 min work/5 min rest. In addition, the subject performed significantly well at 30min/3 min rest compare to 60 min work/5 min rest.

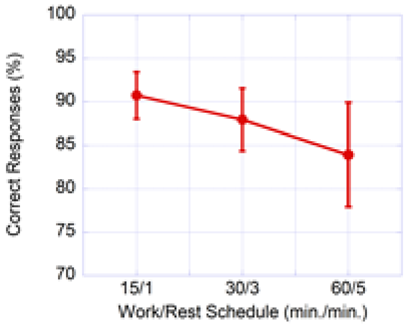

Figure 3. Effect of work/rest schedule on percentage of correct responses.

III.5. Discomfort rating

Only work-rest had a significantly different, F(2,16)=65.38 p<0.000. Duncan test had been employed between the means of work-rest levels. As shown in Figure 4, the subjects significantly felt more comfort at 15 min work/1 min rest compared to 30 min work/3 min rest, p<0.003. Also, the subject significantly felt more comfortable at 15 min work/1 min rest compared to 60 min work/5 min rest, p<0.000. In addition, the subject significantly felt more comfortable 30 min/3 rest compare to 60 min work/5 min rest, p<0.000.

Figure 4. Effect of work/rest schedule on subjects' discomfort ratings.

IV. DISCUSSIONS & CONCLUSIONS

Reviewing the literature indicated that video display terminal (VDT) operators tend to have a high incidence of musculoskeletal problems, visual fatigue, and job stress. Although several ergonomic improvements in workstation design and work environment can help to reduce these problems, a proper work-rest schedule deserves consideration since it is easily applicable and inexpensive. Therefore, the objective of this study was to compare different work-rest schedules for VDT operators considering search tasks. The results indicated that for signal response time, the young subjects reacted not significantly different from the old subjects' performances at the level of 15 minutes work and one-minute rest; however, at 30-minute work and 3-minute rest or 60-minute work and 5 minutes rest, the young subjects reacted significantly faster than the old subjects did. In addition, the subjects significantly had less cardiac stress at 15 min woke/1 min rest compared to 30 min work/3 min rest in terms of heart rates. Also, the subject significantly performed the task with fewer heart rates at 15 min work/1 min rest compared to 60 min work/5 min rest. In addition, those subjects significantly had performed the task with less heart rate at 30 min work/3 min rest compare to 60 min work/ 5 min rest.

The subjects performed significantly well at 15 min work/1 min rest than 30 min/3 min in terms of percentage of correct detection. Also, the subject performed significantly well at 15 min work/1 min rest compared to 60 min work/5 min rest. In addition, the subject performed significantly well at 30 min/3 min rest compare to 60 min work/5 min rest. Finally, in terms of discomfort scale, the subjects significantly felt more comfort at 15 min work/1 min rest than 30 min work/3 min rest. Also, the subject significantly felt more comfortable at 15 min work/1 min rest than 60 min work/5 min rest. In addition, the subject significantly felt more comfortable 30 min/3 rest compare to 60 min work/5 min rest. These results agreed with Balci and Aghazadeh study (2004). Galinsky et al. (2007) provided further converging evidence that supplementary breaks reliably minimize discomfort and eyestrain without impairing productivity.

Generally, the 15 min work/1 min rest schedule resulted in significantly lower discomfort ratings and heart rates and the highest speed, accuracy, and performance for both age groups, compared with the 60/5 and 30/3 schedules. In addition, young subjects were faster reacted than the old subjects in search and comparing tasks. Thus, the comparing task is an excellent task to express the cognitive tasks.

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