American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-6, Issue-1, pp-21-27
www.ajer.org
Research Paper Open Access

Effect of Organized and Self-Managed Breaks on Performance, Physiological, and Subjective Measures in Data Entry, Vigilance, and Cognitive Tasks

Mohamed Z. Ramadan, Ayman M. Ahmed, AbdElatty E. AbdElgawad
(Industrial Engineering Department, Faculty of Engineering, King Saud University, Saudi Arabia)

ABSTRACT:*Clerk performance has received considerable attention over last decades to ensure optimum utilization of human resources. Work/rest schedules have been determined for various kinds of tasks associated with job's difficulties. Most of the early studies were conducted neglecting the freestyle of self-manage breaks in work/rest schedules. The purpose of this research was to investigate the performance characteristics of man while performing different visual tasks (data entry, vigilance, and cognitive) under four work/rest schedules (15/2.5, 30/5, 60/10, and self-organized). Heart rates, percent of correct responses, the number of keystrokes per min, and musculoskeletal discomfort ratings were response variables. Results revealed that 15/2.5 work/rest schedule was superior to the other plans, which provided short rest periods with a long continuous work expressed in higher clerk's performance, subjective measures, and less physiological parameters. The study findings can be applied to different tasks such as data entry, vigilance, and cognitive.*

Keywords: *Productivity, Relief breaks, Visual display terminal, VDT, Work–rest schedule.*

I. INTRODUCTION

To protect operators from the adverse effects associated with work, reducing daily exposure, taking breaks, and rest during work are important [1, 2]. The finding of Zhaojia et al. [3] indicated that longer daily Video Display Terminal (VDT) use, not receiving breaks during VDT work, eyestrain, and musculoskeletal pain is associated with higher scores on the 12-item General Health Questionnaire (GHQ-12). Also, Tucker et al. [4] studied the effect of rest breaks on temporal trends in industrial accident risk, by assessment of accident records from a large engineering company, obtained over a period of 3 years. They found that in the last half-hour of the two hours of continuous work, the relative risk of an accident was higher than in the first half-hour. Those trends in risk did not seem to be differing among the three 2-h work periods. Besides, regular rest breaks seem to be an effective way to control the accumulation of risk during industrial shift-work. Also, the results of Balci and Aghazadeh study [5] indicated that the effect of work–rest plan was considerable on various perceived discomfort categories and the performance of the participants within different types of tasks (i.e., data entry and cognitive). Arrabito et al. [6] presumed that a rest break could restore performance in auditory and visual vigilance tasks. Blasche et al. [7] strengthened rest-break intentions were positively associated with the rate of rest periods (Study 1) and decreased the high level of fatigue and ache over the workday (Study 2).

Thompson and Pullman [8] argued that failing to schedule reliefs in advance will have undesirable outcomes. Atashfeshan and Razavi [9] proposed a model "the Adaptive Control of Thought-Rational (ACT-R) cognitive architecture" that can be applied early in production planning to decrease the adverse effects of mental fatigue by predicting the operator performance. It can also be used for specifying the rest breaks in the design phase without an operator in the loop.

Evidence from several types of research supports the use of exercise and rest breaks in reducing musculoskeletal discomfort in computer tasks. Taylor [10] showed that the activities proposed for “booster breaks” (e.g., physical activity and meditation) promote health, whereas many current work-break practices (e.g., smoking and coffee drinking) do not have the potential to improve workers’ health. This result coincided with other reported studies such as Barredo and Mahon [11] and Samani et al. [12] in which they revealed that active pauses presented to the participants shared with more muscle activity pattern during computer work that might, in the long run, have functional implications for work-related musculoskeletal disorders prevention. However, Verhagen et al. [13] showed that there is a small evidence for the effect of the exercises when compared to massage, adding breaks during computer work, massage as an add-on treatment to manual therapy, or manual therapy as an add-on treatment to exercises.

Research by Lim and Kwok [14] supported a resource/effort-allocation model of fatigue, whereby longer breaks bias participants toward greater effort expenditure on the resumption of the task when cognitive resources may not have been fully replenished. However, longer breaks were also correlating with steeper decrements in performance in the following work activity. These findings may have materializations for the refinement of work-rest schedules in industries where time-on-task degradation in performance is an important concern.

Finally, a study by Mclean et al. [15] demonstrated that providing microbreaks during work did not show any evidence of increasing worker's productivity. However, Faucetta et al. [16] concluded that the introduction of frequent, brief rest breaks might decrease symptoms for workers involved in strenuous work tasks. Self-manage rest breaks are not documented well in the literature. Only two studied [17, 18] raised this topic in the literature with a limited perspective "feedback response." Therefore, the aim of this study was to determine the effect of self-rest breaks and pre-organized rest breaks on the physiological, subjective, and performance of the VDT operators.

II. METHODOLOGY

2.1. Apparatus

The instruments that have been used to perform this study are electrocardiography (ECG), micro-computer, CRT display monitor, keyboard as response station and three software programs written in a Microsoft Visual Studio 6.0. Dark Luminous characters appeared against a white background. English letters were randomly generated and displayed in the middle of the monitor. The application of pressure to the last entry digit in the set activates the clock mechanism to stop and to compute, and record the response time and error rate.

2.2. Participants

Fifteen young clerks (aged between 19 and 26 years), who were paid volunteers, were equally disputed into one of the three tasks in a random fashion. Each group which consisted of five participants was performed only one task. All participants are a normal or fully corrected vision. Also, all are right-handed.

2.3. Independent Factors

2.3.1. Tasks

Type of task consisted of three levels of data entry task, vigilance task, and a cognitive task. These tasks were reported in the process control literature as part of the jobs of human operators; although those tasks are vary in complexities.

2.3.1.1. Data entry task

The task consisted of entering alphanumeric data randomly ordered, and randomly created. This task was selected because entering alphanumeric data is very common in actual office environments. Participants entered the data line exactly as it appeared and then hit a carriage return to initiate new sentences. Entry alphanumeric data task is similar to entering a phone directory listing from a hardcopy document paper. This task was selected because it is very common in actual office environments [5].

2.3.1.2. Psychomotor Vigilance Task

Participants were asked to click on the box as soon as possible after the red clock's numbers appear inside the box. The red numbers appeared at random locations and times. The box covers the screen perimeter. The vigilance task is a similar task in many different fields. In industry, quality control operators have been concerned about a sharp drop in detection flaws. In the military, it has been alarmed by the number of radar contacts being missed by radar operators and the sharp increase in misses with the elapse of time during the World War II [19, 20].

2.3.1.3. Cognitive Task

The cognitive task required participants to do simple arithmetic calculations and enter the result using the keypad. Two digit numbers and arithmetic operators were randomly combined and presented in random order for each experimental session. Mental arithmetic tasks have frequently been used in different studies, which investigate mental workload and attentional demand as a way of representing cognitive task and applicable for the objective of the present study [5, 17].

2.3.2. Rest/Break Periods

As shown in Fig.1, a twice of one-hour of continuous works with a 10-min break schedules (60/10), a fourth of schedules of 30 min of continuous work followed by 5-min breaks (30/5), an eighth continuous works of 15 min followed by 2.5-min breaks were considered in this study similar to the study conducted by Balci1 and Aghazadeh[5]. In addition to a fourth schedule, which included several self-manage breaks of a cumulative time of 20 min in two hours work, was also incorporated into the study. The total duration of the experiment was 150 min, for each rest/break period, which consists of a total of 120 min VDT work and 30 min of rest including two of 10-min preparation and ending phases to all rest/work schedules.

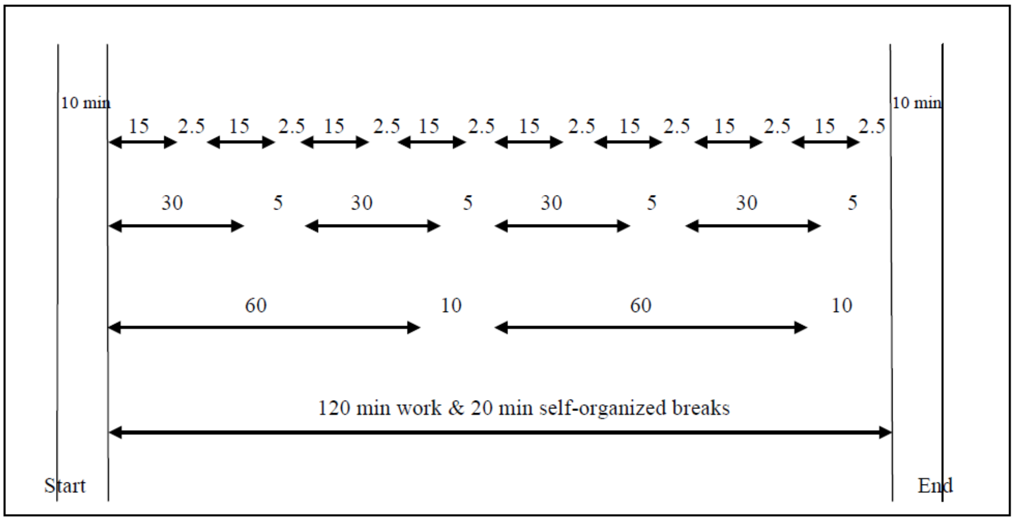

Fig.1 Time intervals for various work/rest schedules with constant ratio of 6/1.

2.4. Response Variables

2.4.1. Performance measures

Keystroke rate (average number of keystrokes per minute) and correct responses (percentage of characters without errors) were each scored separately.

2.4.2. Subjective measure

Participants rated their musculoskeletal discomfort before and after the 120-min work period for five areas of their body: neck and shoulders, back, arms and hands, legs and feet, and eyes on a modified General Discomfort Rating Scale. On 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 was implemented. It was felt that the modified General Discomfort Rating Scale would provide finer discrimination than that obtained by having participants 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.

2.4.3. Cardiac response

The Electrocardiogram (EKG) was recorded using BiosigInsta-Pulse heart rate monitor #BIS-203. Instruments were calibrated based on their manufacture procedures.

2.5. Experimental Design and Procedures

After providing written consent and collecting demographic data, participants were instrumented for heart monitoring, trained on the computer task, and were shown how to respond via the keyboard to questionnaires that appeared on the VDT. Participants then responded to the pre-musculoskeletal questionnaires and performed the computer task for two hours in each work/rest period. Following completion of the task, participants completed musculoskeletal discomfort ratings. In addition to subjective measures, they were asked to rate the task difficulty, their effort, and the degree of time pressure they felt based on ad hoc generated Likert scales. Finally, information about break preferences was acquired at the end of the experimental session from each participant.

Each participant performed all treatment pauses within the assigned task. The participants had received one training session followed by test days. During the training session, the participants were given their feedback performances to teach them to keep their performances as high as possible. On the test days, participants were constructed to refrain from consuming any food or coffee at least three hours before his scheduled session. The actual experiment was started with a pre-work rest period where the participant was seated, so his physiological parameters stabilized. Participant performed each treatment in a randomized order. The beginning and the end of each regular break was announced to the participants by the experimenter except the self-manage rest-breaks. During each break, participants were instructed to sit relaxed in their chair as not productive time.

Signals were composed of character that was 8 mm wide by 10 mm high and was viewed from about 50 cm. Again, the participant's task was to push an appropriate button in response station as quickly as possible while keeping accuracy as high as possible. Continuous signals were presented for each test treatment. The participant permitted 3000 ms to respond to a signal after it is presented. If the participant failed to respond within this period, his score was calculated as a miss. The participant 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.

Several ANCOVAs employed for analyzing depended variables using the statistical package for social sciences (SPSS/PC+ software, version 22). The response variables were task type (data entry, vigilance, and cognitive tasks), and work/rest schedule (15/2.5, 30/5, 60/10, and 120 work/free 20 rest). Pre-work scores were used as covariates to adjust for individual differences for cardiac effort and discomfort ratings. Performance measures had no covariate values. The first 3 min of the keystroke, data of discomfort ratings and heart rate were used for the covariates. Results were considered statistically significant at $p<0.05$. In a case of significant of main variables and a significant of their level of interaction, the only higher level of interaction was analyzed neglecting to analyze their main effects. A modified scale of discomfort was presented to the participant in a sheet of paper after the participant executed the trials of the assigned treatment.

III. RESULTS

3.1. Number of keystrokes per minute

Results showed that both of the main variables had significant effects on human performance as well as there was an interaction between the main effects. task, $F(2,48)=1554.3$, $p<0.0001$; work-rest, $F(3,48)=18.8$, $p<0.0001$; task by work-rest interaction, $F(6,48)=10.8$, $p<0.0001$. As shown in Fig.2, Duncan test had been employed between the means of work- rest levels among the three different task types. At the entry data task, the participants significantly had highest hitting the keys at 15/2.5 schedule when compared to all other work-rest schedules. At vigilance task, participants significantly reacted differently from one schedule to the others. They have optimally performed the task in 15/2.5 schedule when compared to the others. Finally, at the cognitive task, participants significantly solved problems and hit keys faster with 15/2.5 and 30/5 work-rest schedules when compared to the other two schedules.

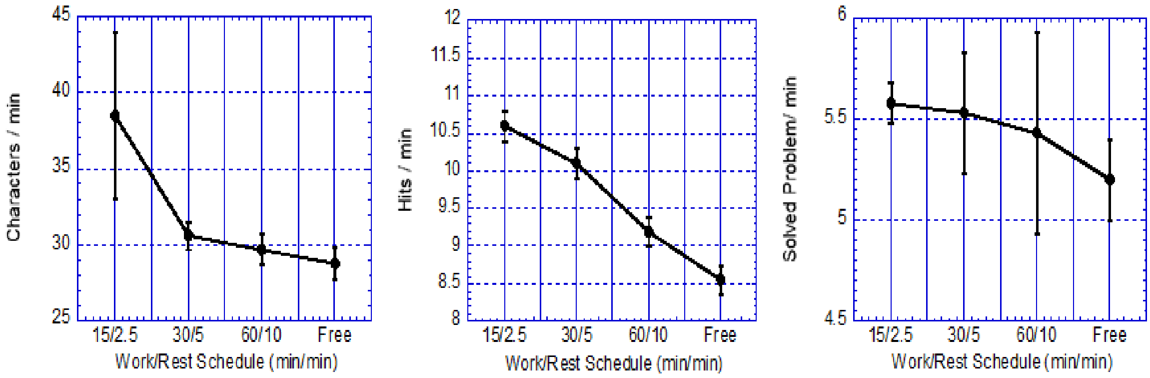

Fig.2 Effect of task type by work/rest schedule interaction on hitting keys per min.

3.2. Percentage of correct responses

Results showed that both of the main factors had significant effects on human performance as well as there was an interaction between the main effects. task, $F(2,48)=194.9$, $p<0.0001$; work-rest, $F(3,48)=31.0$, $p<0.0001$; task by work-rest interaction, $F(6,48)=27.5$, $p<0.0001$. As shown in Fig.3, Duncan test had been employed between the means of work- rest levels among the three different task types. At the entry data task, the participants significantly had the highest performance at 15/2.5 schedule when compared to all other work-rest schedules. At vigilance task, participants significantly correct reacted at both 30/5 and self-organized schedules when compared to other schedules. However, at the cognitive task, participants significantly performed well at 15/2.5 and self-organized work-rest schedules when compared to the 30/5 schedule. In addition, there was no significant difference between participants' performances at 60/10 and self-organized schedule.

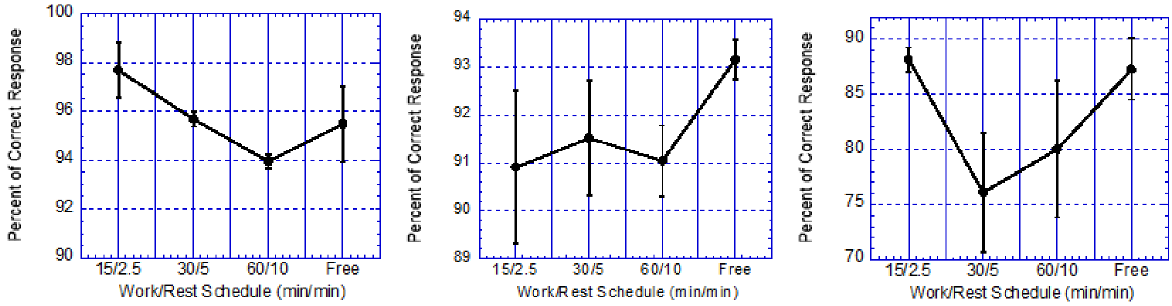

Fig.3 Effect of task type by work/rest schedules interaction on percent of correct responses.

3.3. Cardiac Effort

Results showed that both of the main factors had significant effects on hear rate as well as there was an interaction between the main effects. task, F(2,47)=4.6, p<0.014; work-rest, F(3,47)=7.6, p<0.0001; task by work-rest interaction, F(6,47)=5.77, p<0.0001. As shown in Fig.4, Duncan test had been employed between the means of work- rest levels among the three different task types. At the entry data task, the participants significantly had a less cardiac effort at 15/2.5 and self-organized schedules when compared to the other work-rest schedules. In addition, the participants significantly had a less cardiac effort at self-organized and 30/5 schedules when compared to the 60/10 work-rest schedule. At vigilance task, participants' cardiac efforts were not significantly different from one to another of the work-rest schedules. However, at the cognitive task, the participants significantly had a less cardiac effort at 15/2.5 and self-organized woke/rest schedules when compared to 30/5 and 60/10 woke/rest schedules. Also, no significant differences between participants' heart rates in both 30/5 and 60/10 woke/rest schedules.

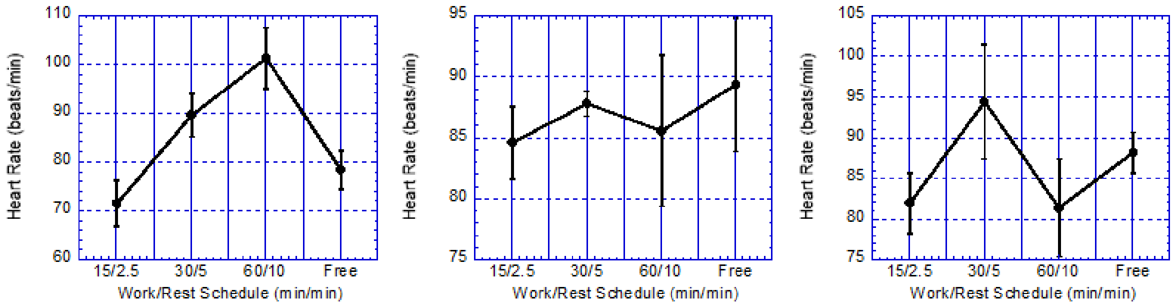

Fig.4 Effect of task type by work/rest schedules interaction on the cardiac effort.

3.4. Discomfort rating

Among all assigned body parts except in leg and feet regions, only work-rest schedules were significant on discomfort ratings, neck and shoulder, F(3,47)=27.55, p<0.0001; back, F(3,47)=31.4, p<0.0001; arms and hands, F(3,47)=34.3, p<0.0001; and eyes, F(3,47)=28.4, p<0.0001. Duncan test had been employed between the means of work rest level. As shown in Fig. 5, the participants significantly felt more discomfort at 60/10 min work-rest schedule when compared to the other schedules, p<0.0001. This result was matched in the following four body parts, as shown in Fig. 5.

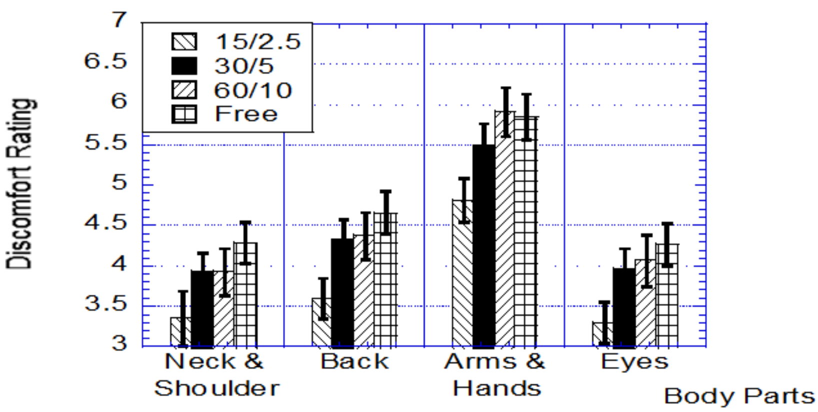

Fig.5 Effect of work/rest schedules on participants' discomfort ratings.

IV. DISCUSSIONS & CONCLUSIONS

Consideration of the literature survey showed that video display terminal operators (VDT) tend to have a high incidence of musculoskeletal disorders, visual fatigue, and job discomfort [4, 5, 15]. Although some ergonomic improvements in workstation design and work environment would help to reduce these cases; a suitable work-rest schedule deserves consideration since it is readily applicable and inexpensive. The objective of this study was to compare the work-rest schedules for VDT operators considering three different industrial tasks. An experiment was conducted with 15 male clerks in a computer use as participants. The methodology included discomfort questionnaire, cardiac and performance measures. The performance measures were the percentage of correct responses and number of keystrokes per minute. The independent variables were the work-rest schedule (15/2.5, 30/5, 60/6, and self-organized rest schedules) and the three task types.

In terms of the number of keystrokes per minute, the participants significantly faster reacted at the 15/2.5 work/rest schedule within three different tasks when compared to the other work/rest schedules. Also, the participants' accuracies were depending on the job types. For example, at entry data and cognitive tasks, participants significantly worked with high efficiencies concerning the percentage of correct responses when compared with other work/rest schedules. However, at vigilance task, participants significantly collaborated with less accuracy regarding the percentage of correct responses when compared with other work/rest schedules. Concerning cardiac effort, the participants significantly had less cardiac stress at the 15/2.5 work/rest schedule when compared to the other plans for entry and cognitive tasks. Finally, regarding discomfort scale, the participants significantly felt more comfort at the 15/2.5 work/rest schedule when compared to other work/rest schedules. Results from previous studies proved that valuable research predecessor events could be changed depending on the task types. However, results of this study demonstrate the agreement among different work types.

After analyzing the statement of participant satisfaction (not reported here) regarding the task difficulty, their effort, the degree of time pressure they felt, and work/rest preference. They agreed with the study results. Generally, the 15-min work/2.5 min rest schedule resulted in significantly less discomfort rating and cardiac effort as well as the highest performance speed and accuracy when compared to the 30/5 and 60/10 schedules. The experimental tasks were selected to express most of the VDT employed in industrial sectors.

REFERENCES

[1]. AE Dembe, JB Erickson, RG Delbos, SM Banks, The impact of overtime and long work hours on occupational injuries and illnesses: new evidence from the United States, Occupationaland EnvironmentalMedicine, 62, 2005, 588–597.doi:10.1136/oem.2004.016667

[2]. A Witkoski, V. Dickson, Hospital Staff Nurses' Work Hours, Meal Periods, and Rest Breaks,the American Association of Occupational Health Nurses Journal, 58 (11), 2010, 489-497.

[3]. Ye Zhaojia, YAbe, Y Kusano, N Takamura, K Eida, T Takemoto, K Aoyagi, The Influence of Visual Display Terminal Use on the Physical and Mental Conditions of Administrative Staff in Japan,Journal of Physiological Anthropology, 26, 2007, 69-73.

[4]. P Tucker, S.Folkard,I. Macdonald, Rest breaks and accident risk. Lancet 361, 2003, 680.

[5]. R Balci, F Aghazadeh, Effects of exercise breaks on performance, muscular load, and perceived discomfort in data entry and cognitive tasks, Computers & Industrial Engineering, 46, 2004, 399–411.doi:10.1016/j.cie.2004.01.003

[6]. GR Arrabito, G Ho, B Aghaei, C Burns, MHou, Sustained Attention in Auditory and Visual Monitoring Tasks: Evaluation of the Administration of a Rest Break or Exogenous VibrotactileSignals,Human Factors,57(8),2015, 1403–1416. doi:10.1177/0018720815598433

[7]. G Blasche, SPasalic, V Bauböck, DHaluza, R Schoberberger, Effects of Rest-Break Intention on Rest-Break Frequency and Work-Related Fatigue, Human Factors, xx(xx), 2016, 1-10. doi:10.1177/0018720816671605

[8]. GM Thompson, ME Pullman,Scheduling workforce relief breaks in advance versus in real-time, European Journal of Operational Research, 181, 2007, 139–155. doi:10.1016/j.ejor.2006.05.018

[9]. N Atashfeshan, HRazavi, Determination of the Proper Rest Time for a Cyclic Mental Task Using ACT-R Architecture. Human Factors,xx(xx), 2016, 1-15. doi: 10.1177/0018720816670767

[10]. WC Taylor, Transforming Work Breaks to Promote Health, American Journal of Preventive Medicine, 29(5), 2005, 461–465. doi:10.1016/j.ampre.2005.08.040

[11]. R Barredo, K Mahon, The effect of exercise and rest breaks on Musculoskeletal Discomfort during computer tasks: An evidence-based perspective, Journal ofPhysicalTherapy Science, 19, 2007, 151-163.

[12]. A Samani, A Holtermann, K Sogaard, P Madeleine, Active pauses induce more variable electromyographic pattern of the trapezius muscle activity during computer work, Journal of Electromyographyand Kinesiology, 19, 2009, e430–e437.

[13]. AP Verhagen, C Karels, SM Bierma-Zeinstra, A Feleus, SDahaghin, ABurdorf, BW Koes, Exercise proves effective in a systematic review of work-related complaints of the arm, neck, or shoulder, Journal of Clinical Epidemiology 60, 2007, 110-117. doi:10.1016/j.jclinepi.2006.05.006

[14]. J Lim, K Kwok, The Effects of Varying Break Length on Attention and Time on Task, Human Factors, 58(3), 2016, 472–481. doi:10.1177/0018720815617395

[15]. L McLean, M Tingley, RN Scott, J Rickards, Computer terminal work and the benefit of microbreaks, Applied Ergonomics, 32, 2001, 225-237.

[16]. J Faucetta, J Meyersb, J Milesc, I Janowitzd, FFathallah, Rest break interventions in stoop labor tasks, Applied Ergonomics, 38, 2007, 219–226. doi:10.1016/j.apergo.2006.02.003

[17]. RA Henning, EA Callaghan, JI Guttman, HA Braun, Evaluation of Two Self-Managed Rest Break Systems for VDT Users, 39 (12),1995, 780-784. doi:10.1177/154193129503901207

[18]. RA Henning, EA Callaghan, AM Ortega, GV Kissel, JI Guttman, H.A. Braun, Continuous feedback to promote self- management of rest breaks during computer use, International Journal of Industrial Ergonomics, 18, 1996, 71-82.doi: 10.1016/0169-8141(95)00032-1

[19]. AAriga, ALleras, Brief and rare mental ''breaks'' keep you focused: Deactivation and reactivation of task goals preempt vigilance decrements, Cognition 118, 2011, 439–443. doi:10.1016/j.cognition.2010.12.007

[20]. WS Helton, PN Russell, Rest is best: The role of rest and task interruptions on vigilance, Cognition, 134, 2015, 165–173. http://dx.doi.org/10.1016/j.cognition.2014.10.001