Effect of ergonomic intervention on cognitive function of office workers

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Research Article

Keywords: cognitive function, ergonomic intervention, office worker, working memory, attention

Posted Date: March 8th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1419960/v1

Abstract

Introduction: This study was designed to assess the effect of an ergonomic training intervention on the cognitive function of office workers.

Materials and methods: This was a before-after study performed in 2020 in Yazd, Iran on female office workers. Cognitive function (working memory, attention and response time) was assessed by Wechsler working memory and Stroop test before and after the intervention. Ergonomic intervention consisted of ergonomic modification of the workstation and a training program about ergonomic principles of office work. Data were analyzed by SPSS (ver. 24) using paired T-test and multiple regression linear model.

Results: Mean age and work experience of the participants was 35.38±1.60 yr., and 8.54± 1.24 yr., respectively. Forward visual memory, response time and interference time were significantly changed after the intervention, but the change in other aspects of cognitive function (i.e. memory span, backward visual memory, and interference score) was not statistically significant. Marital status, age and working hours significantly affected working memory, test duration and response time, and number of errors, respectively.

Conclusion: This study showed that ergonomic intervention (modification of workstation and training) may significantly affect some aspects of cognitive function in office workers.

Introduction

During the last 50 years, new technologies especially computer use has changed workstations and has led to increased number of sedentary jobs (Russell et al. 2016). It has been estimated that most of office workers in Australia spend about 75% of their workday in a sedentary position. Prolonged sitting (more than 4 hours a day) is associated with some adverse health effects, such as metabolic, cardiovascular and musculoskeletal disorders (Russell et al. 2016). Workplace interventions such as ergonomic modifications and posture change during a static position in the workplace may decrease some adverse effects of prolonged sitting (Healy et al. 2012; Pronk et al. 2012). Recently, besides metabolic and musculoskeletal disorders, the effect of static or sedentary posture or non-ergonomic situations on cognitive function has raised concern as well (Schultz et al. 2007).

Office work, in order to be performed perfectly, needs many aspects of cognitive function. Cognitive function consists of such domains as perception, attention, memory and decision making (Munabi et al. 2014; Sharifnia et al. 2010), which is probably affected by many factors, such as work tasks, time of work, shift work, some environmental factors and even body posture during work (Grunseit et al. 2013; Mohammadi & Roshanzadeh 2014). The effect of body posture on cognitive function is important, especially in the tasks which require a high level of attention and concentration (Schraefel et al. 2012). Inappropriate body posture can lead to increased human errors and delay in information processing (Mohammadi & Roshanzadeh 2014).

Most office works are routinely performed in a sitting and mostly static position. Many office workstations lack the standards of an ergonomic workstation which may affect physical and cognitive aspects of health. Effect of ergonomic modifications and workplace exercises on physical health have been widely assessed, but its effect on cognitive function is controversial. Workstation redesign especially using ergonomic and appropriate chairs may have an important role in the workers' performance and comfort (Mueller & Hassenzahl 2010). Ergonomic intervention in the workplace in order to design a better workstation, and workplace exercises may improve cognitive function and performance (Healy et al. 2011; Mohammadi et al. 2018). Some studies have shown a better cognitive function in non-sitting work positions (Ebara et al. 2008; Grunseit et al. 2013; Isip 2014). Employees have reported less tiredness and higher concentration in non-sitting positions 2018; Schultz et al. 2007), but Magnon et al. (2018) in a systematic review didn't find a significant effect of reducing sedentary behavior on cognitive function. Schwartz et al. (2018) and Russel et al. (2016) did not find a significant effect for intermittent sitting and standing positions on cognitive function, but in another study on telephone operators, standing position increased productivity (Garrett et al. 2016). Schwarz et al. (2018) found that body posture did not affect response time, concentration, and work pace, but Mohammadi et al. (2018) found that cognitive function is affected by work posture. Baker et al. in two different studies found that two hours of sitting computer work increased problem solving errors, but attention did not change (Baker et al. 2018), and two hours of standing computer work increased discomfort and deteriorated reaction time and mental state, while creative problem-solving improved (Baker et al. 2018).

So, due to inconsistent results in the previous studies, this study was designed to assess the effect of an ergonomic intervention program, including ergonomic modification of the workstation and training about ergonomic workstation standards and workplace exercises, on the cognitive function of office workers.

Materials And Methods

This was a before-after study performed in 2021 in Yazd, Iran. Participants were female office workers of the Public Health school in Shahid Sadoughi University of Medical Sciences who were randomly selected from all office workers. The number of male office workers was small, so only females were selected. In order to decrease the effect of environmental factors, the participants were selected from one school and their participation in the study was voluntary. Inclusion criteria were: work experience of at least 1 year as an office worker, age between 25 and 45 years and at least 2 hours of computer work in their work shift. Those with sleep disorders, and consumption of psychiatric drugs did not enter the study.

Demographic information (age, work experience, and average working hours a day) was collected by a questionnaire. Then a researcher-made questionnaire was used to assess ergonomic features of the workplace by an expert occupational hygienist and ergonomic risk factors were recorded in each workstation to be used in designing the training content.

Cognitive function assessment

Cognitive function was assessed for each participant in her workstation in similar situations at 11 o'clock AM. Wechsler working memory and Stroop test were used in this regard. Working memory was assessed using Wechsler working memory test. Other studies have used this test for measuring working memory (Garrett et al. 2016). In this test, a set of digits (from three to nine digits) are presented in the monitor and the participant should repeat the digits in forward and backward directions. At the end, forward and backward visual memory and memory span will be measured. After two errors, the test is terminated.

Attention and response time were measured by Stroop test. In this test, four words (green, blue, red and yellow) are presented on the monitor for 2 seconds with 0.008 s time interval. Forty eight words are congruent with the color (e.g. word "green" with green color) and 48 words are incongruent with the color (e.g. word "green" with blue color). The participants should respond to the color of the word not its meaning, and press the specific button in the keyboard. Attention is determined by calculating interference score by subtracting the number of incongruent correct answers from congruent correct answers. Response time is determined by calculating interference time which is calculated by subtracting response time to incongruent words from congruent words.

Intervention:

After initial evaluations of the workstation and performing cognitive tests, ergonomic intervention was performed. Intervention consisted of two parts: 1. one session of training ergonomic principles of office work with emphasis on ergonomic risk factors of the participant's workstation which were extracted in the previous stage, including the standard arrangement of the workstation, adjusting the chair, appropriate posture during work, micro-breaks and stretching exercises in the workplace. Trainings were performed by an expert occupational hygienist separately for each participant by face to face education. The training session lasted about half an hour for each participant; 2. Ergonomic modification of the workstation including adjusting the chair height, and standard positioning of mouse, keyboard and monitor. No change was done to workplace equipment. One month after the intervention, cognitive tests were performed again at the same situations. During this period, the workstations were checked every other day to answer the questions of the participants and seek any environmental or other confounding factors.

Statistical analysis:

Data were analyzed by SPSS (ver. 24) using paired T-test and multiple regression linear model. Uni-variate analysis showed that some demographic factors affected the responses, so the effect of age, marital status, and working hours on the results of the tests were assessed in a regression model. In this model, the initial result of each test was used as a confounder in the model.

Ethical issues:

This study was the result of a master thesis in occupational health and was approved by the ethics committee of Shahid Sadoughi university of medical sciences (code: IR.SSU.SPH.REC.1399.083). An informed consent was obtained from each participant.

Results

Totally, 37 female office workers entered the study. Table 1 shows demographic data of the participants.

Table 1
Demographic data of the participants.

Variable	Mean ± SD
Age (yr.)	35.38 ± 1.60
BMI (Kg/m^2)	24.84 ± 3.84
Work experience (Yr.)	8.54 ± 1.24
Working hour (hr.)/day	7.59 ± 0.19
Education	12 (3.24%)
Bs.	24 (64.9%)
Msc.	1 (2.7%)
PhD.	

Forward visual memory and response time were significantly changed after the intervention. Table 2 compares various cognitive variables before and after intervention.

Table 2
Comparison of cognitive variables before and after intervention.

Cognitive variable		Mean ± SD		P value
		Before intervention	After intervention	
Working memory	Memory span	6.49 ± 0.26	7.08 ± 0.23	0.07
	Forward visual memory	7.46 ± 2.86	8.91 ± 2.67	0.01
	Backward visual memory	8.92 ± 2.95	9.18 ± 2.84	0.60
Attention and response time	Test duration (s)	95.67 ± 11.95	90.89 ± 13.34	0.004
	Response time (s)	2005.02 ± 238.62	1901.89 ± 269.53	0.002
	Number of errors	0.55 ± 1.52	0.44 ± 0.84	0.77
	Interference score	2.00 ± 1.38	0.41 ± 0.34	0.11
	Interference time	70.05 ± 11.10	48.64 ± 7.65	0.01

Some demographic variables significantly affected various parameters of cognitive function (Table 3). Marital status significantly affected working memory, but age and work experience did not significantly affect this cognitive parameter. Age, but not marital status and working hours, significantly affected test duration and response time after the intervention. Number of errors was significantly affected by working hours.

Table 3
Effect of age, marital status and working hours on various cognitive parameters.

Cognitive variable		Regression coefficient (P value)			
		Age	Marital status	Working hours	Baseline
Working memory	Memory span	0.028(0.247)	1.204(0.036)*	0.174(0.316)	0.38(0.005)*
	Forward visual memory	0.069(0.143)	2.753(0.008)*	0.157(0.625)	0.371(0.012)*
	Backward visual memory	0.017(0.611)	0.626(0.428)	1.036(< 0.001)*	0.523(< 0.001)*
Attention and response time	Test duration(s)	0.396(0.016)*	-3.242(0.372)	0.954(0.425)	0.674(< 0.001)*
	Response time(s)	7.891(0.023)*	-63.766(0.422)	23.131(0.351)	0.665(< 0.001)*
	Number of errors	-0.014(0.117)	0.036(0.872)	0.177(0.010)	0.417(< 0.001)*
	Interference score	0.000(0.987)	-0.269(0.463)	-0.163(0.152)	0.614(< 0.001)*
	Interference time	0.065(0.930)	24.033(0.174)	10.598(0.053)	0.356(< 0.001)*

* Significant effect.

Discussion

In this study, the effect of an ergonomic intervention (i.e. ergonomic modification and training) on cognitive function was assessed in office workers. Wechsler working memory and Stroop tests were used to assess cognitive function before and after ergonomic intervention in female office workers. The results showed that forward visual memory, response time and interference time were significantly changed after the intervention, and some demographic and occupational variables, especially age, significantly affected the participants' response after the intervention.

To assess short-term and active working memory, memory span was measured using Wechsler working memory test. This test can assess forward visual memory, backward visual memory and memory span based on the golden digit (7 ± 2), and its score is usually between 5 and 9 in the adults. Greater score of working memory shows a better memory function. Some previous studies have assessed the effect of different variables on working memory. Barella et al. (2010) found that posture modification positively affects working memory. Chang et al. in a systematic review found a positive effect of exercise on short-term memory (Chang et al. 2012).

In this study, consistent with Russel et al. study (2018) the score of all aspects of working memory (i.e. memory span, and forward and backward visual memory) were increased after the intervention, but the difference was significant only for forward visual memory which was consistent with the study of Bantoft et al. (2016); although the level of significance for memory span was near significance and increasing sample size may lead to a significant difference. Working memory is a part of cognitive system which stores information and also holds some information while performing mental tasks (Bantoft et al. 2016). Working memory affects attention and concentration as well (Alloway et al. 2010; Hill et al. 2010). So, its deficit may lead to errors in the workplace.

In the current study, attention and response time were assessed by Stroop test. This test has been designed to measure attention and cognitive flexibility by visual processing. Interference score shows attention, and response score shows response or reaction time. Usually, response time to congruent words is shorter than incongruent ones. When interference time is shorter, the time of stimulus control is shorter and the participant can differentiate between the color and the meaning in a shorter duration of time. Interference score is an index of human brain capability in the management of new tasks. Lower interference score shows a better performance, less errors and higher attention. In the current study, interference score was decreased after the intervention, although this decrease was not statistically significant.

Test duration was significantly decreased after the intervention which shows higher speed of the participants in response and reaction. This result was consistent with the results of Mohammadi et al. (2018) and inconsistent with the studies conducted by Shwartz et al. (2018; 2019); although it should be considered that in all of these studies the intervention was different with the current study. Response time significantly reduced after the intervention, but the change in the number of errors was not statistically significant. Zhang et al. (2018) in a study on students found that dynamic workstation cannot affect the results of Stroop test, although again the intervention was different from our study and the results cannot be compared.

Interference score in the current study was decreased after the intervention which shows a lower probability of error and a better performance in the workplace; although the decrease was not statistically significant, the difference was large and a larger sample size may lead to a significant difference. Mohammadi et al. (2018) found that interference score and selective attention in the standard sitting position was better than other positions. Russell et al. (2016) found that after their intervention, attention was improved. Unfortunately, we couldn't find a study with a similar intervention with the current study.

In this study, interference time after the intervention was significantly decreased, which shows a higher speed and lower response time, which was inconsistent with the results of Schwartz et al. (2018). Most studies on the effects of ergonomic modification in the workplace have been conducted on the musculoskeletal complaints and disorders (Torbeyns et al. 2014; Mehrparvar et al. 2–14).

Some factors may affect cognitive function in the workplace. Working hours, shift work, work posture, and some environmental exposures are among the factors which have been assessed in different studies

(Esmaily et al. 2020; Schwartz et al. 2019; Schwartz et al. 2018; Zeydabadi et al. 2019). Ergonomic interventions to improve work posture, workplace arrangement, micro-breaks and stretching exercises have been shown to improve discomfort, fatigue and musculoskeletal complaints in different jobs (Torbeyns et al. 2014; Pronk et al. 2011; Lee et al. 2021), but the effect of interventions on workers' cognitive function is controversial by now. Most studies in this regard have assessed the effect of changing work posture on cognitive function. Schwartz et al. in two different studies found that sit-stand work posture as an ergonomic modification cannot affect cognitive function in short and medium-term durations (Schwartz et al., 2019; Schwartz et al., 2018). They showed that intermittent work posture did not affect response time, concentration and work speed (Schwartz et al., 2018), which was inconsistent with the results of the current study, although our modification was ergonomic modification of the workplace and training, but they compared two different work postures. Russel et al. couldn't find a significant effect of intermittent sitting and standing postures on cognitive function in office workers (Russell et al., 2016). Mohammadi et al. (2018) conversely found that work posture can significantly affect cognitive function. Bantoft et al. assessed the effect of standing and walking during work on cognitive function and didn't find a significant effect (Bantoft et al., 2016). Magnon et al. in a systematic review found that interventions to reduce sedentary behavior is not associated with changes in cognitive function (Magnon et al. 2018). Sohrabi & Babamiri (2021) found a significant effect of an ergonomic training intervention on musculoskeletal complaints of office workers, but this effect was not observed on productivity and some variables of quality of work-life.

In the current study, marital status significantly affected the difference after the intervention, so as the impact of intervention was higher in single individuals than married ones, which is probably due to family or social preoccupations in married individuals. Age and work history did not affect working memory, but it was affected by daily working hours. Response time was significantly increased by age. Increased daily working hours significantly increased the number of errors after the intervention.

Limitations: This study had some limitations. The participants were only females, so the results cannot be generalized to males. The assessment was done one month after the intervention, so the long-term effects of the intervention could not be assessed. The small sample size may have affected the significance of some differences. We couldn't change any non-ergonomic equipment due to monetary constraints, and our modification consisted only of standard arrangement and adjustment of different equipment in the workstation.

Conclusion

This study showed that ergonomic intervention including training and ergonomic modification of the workstation may significantly affect some aspects of cognitive function (i.e. forward visual memory, response time and interference time) in office workers in short-term duration. Larger studies with higher sample size, other ergonomic interventions and also longer duration of assessment is recommended.

Declarations

Acknowledgements: The authors are grateful to the head of public health faculty and all staff of the faculty who collaborated in this study.

Author contributions: All author have contributed in this study in the following roles: ZM (proposal preparation, data collection, preparing article draft), GH (initial concept, data interpretation, final preparation of manuscript), SB (data analysis, data interpretation, preparation of initial draft), AHM (initial concept, data interpretation, preparation of initial draft, final preparation of manuscript)

Conflict of interest:

The authors declare that there is no conflict of interest.

References

1. Alloway TP, Elliott J, Place M (2010) Investigating the relationship between attention And working memory in clinical and community samples. Child Neuropsychol 16: 242-254. DOI: 10.1080/09297040903559655.
2. Baker R, Coenen P, Howie E, Williamson A, Straker L (2018) The short term musculoskeletal and cognitive effects of prolonged sitting during office computer work. Int J Environ Res Public Health 15(8):1678. doi: 10.3390/ijerph15081678.
3. Baker R, Coenen P, Howie E, Lee J, Williamson A, Straker L (2018) A detailed description of the short-term musculoskeletal and cognitive effects of prolonged standing for office computer work. Ergonomics 61(7):877-890. doi: 10.1080/00140139.2017.
4. Barella LA, Etnier JL, Chang Y-K (2010) The immediate and delayed effects of an acute bout of exercise on cognitive performance of healthy older adults. J Aging Phys Act 18(1):87-98.
5. Bantoft C, Summers MJ, Tranent PJ, Palmer MA, Cooley PD, Pedersen SJ (2016) Effect of standing or walking at a workstation on cognitive function: a randomized counterbalanced trial. Human factors 58(1): 140-149.
6. Brakenridge CL, Healy GN, Hadgraft NT, Young DC, Fjeldsoe BS (2018) Australian employee perceptions of an organizational-level intervention to reduce sitting. Health Promot Int 33(6): 968-979.
7. Chang Y-K, Labban JD, Gapin JI, Etnier JL (2012) The effects of acute exercise on cognitive performance: a meta-analysis, Brain Res 1453:87-101.
8. Ebara T, Kubo T, Inoue T, Murasaki GI, Takeyama H, Sato T, et al. (2008) Effects of adjustable sit-stand VDT workstations on workers' musculoskeletal discomfort, alertness and performance. Ind Health 46(5): 497-505.
9. Esmaily A, Jambarsang S, Mohammadian F, Mehrparvar AH (2020) Effect of shift work on working memory, attention and response time in nurses. JOSE: 1-19. DOI: 10.1080/10803548.2020.1863656.
10. Garrett G, Benden M, Mehta R, Pickens A, Peres SC, Zhao H (2016) Call center productivity over 6 months following a standing desk intervention.

IISE Trans Occup Ergon Hum Factors 4(2-3): 188-195.

11. Grunseit AC, Chau JYY, Van der Ploeg HP, Bauman A (2013). “Thinking on your feet”: A qualitative evaluation of sit-stand desks in an Australian workplace. BMC Public Health 13(1): 365.
12. Hill BD, Elliott EM, Shelton JT, Pella RD, O’Jile JR, Gouvier WD (2010) Can we improve the clinical assessment of working memory? An evaluation of the Wechsler Adult Intelligence Scale-Third Edition using a working memory criterion construct, J Clin Exp Neuropsychol 32 (3): 315-323. DOI: 10.1080/13803390903032529.
13. Healy G, Lawler S, Thorp A, Neuhaus M, Robson E, Owen N, Dunstan D (2012) Reducing prolonged sitting in the workplace. Victorian Health Promotion Foundation, Melbourne, Australia.
14. Healy GN, Matthews CE, Dunstan DW, Winkler EA, Owen N (2011) Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003–06. Europ Heart J 32(5): 590-597.
15. Isip MIG (2014) Effect of a Standing Body Position during College Students’ Exam: Implications on Cognitive Test Performance. Ind Eng Manag Syst 13(2): 185-192.
16. Knight AP & Baer M (2014) Get up, stand up: The effects of a non-sedentary workspace on information elaboration and group performance. Soc Psychol Personal Sci 5(8): 910-917.
17. Lee S, DE Barros FC, DE Castro CSM, DE Oliveira Sato T (2021) Effect of an ergonomic intervention involving workstation adjustments on musculoskeletal pain in office workers-a randomized controlled clinical trial, Ind Health 59(2):78-85. doi: 10.2486/indhealth.2020-0188.
18. Magnon V, Vallet GT, Auxiette C (2018) Sedentary behavior at work and cognitive functioning: A systematic review. Front Public Health; 6: 239.
19. Mehrparvar AH, Heydari M, Mirmohammadi SJ, Mostaghaci M, Davari MH, Taheri M (2014) Ergonomic intervention, workplace exercises and musculoskeletal complaints: a comparative study, Med J Islam Repub Iran 28:69. PMID: 25405134; PMCID: PMC4219902.
20. Mohammadi S, Mokhtarinia HR, Jafarpisheh AS, Kasaeian A, Osqueizadeh R (2018) Investigating the Effects of Different Working Postures on Cognitive Performance. Arch Rehabil 18(4): 268-277. doi: 10.21859/jrehab.18.4.1
21. Mohammadi S & Roshanzadeh M (2014) The relationship between psychological empowerment and psychological strain among clinical nurses in educational hospitals. J Nurs Manag 3(3): 51-60
22. Mueller GF & Hassenzahl M (2010) Sitting Comfort of Ergonomic Office Chairs—Developed Versus Intuitive Evaluation. JOSE 16(3); 369-374.
23. Munabi IG, Buwembo W, Kitara DL, Ochieng J, Mwaka ES (2014) Musculoskeletal disorder risk factors among nursing professionals in low resource settings: a cross-sectional study in Uganda. BMC nursing 13(1): 1-8.
24. Pronk NP, Katz AS, Lowry M, Payfer JR (2012) Peer reviewed: reducing occupational sitting time and improving worker health: the take-a-stand project, 2011. Prev Chronic Dis 9:E154. DOI: 10.5888/pcd9.110323.

25. Russell BA, Summers MJ, Tranent PJ, Palmer MA, Cooley PD, Pedersen SJ (2016) A randomised control trial of the cognitive effects of working in a seated as opposed to a standing position in office workers. Ergonomics 59(6): 737-744.
26. Schraefel M, Jay K, Andersen LL (2012) Assessing the effect of self-positioning on cognitive executive function. J Ergon 2: 1-5.
27. Schultz IZ, Stowell AW, Feuerstein M, Gatchel RJ (2007) Models of return to work for musculoskeletal disorders. J Occup Rehabil 17(2): 327-352.
28. Schwartz B, Kapellusch JM, Baca A, Wessner B (2019) Medium-term effects of a two-desk sit/stand workstation on cognitive performance and workload for healthy people performing sedentary work: a secondary analysis of a randomised controlled trial. Ergonomics 62(6): 794-810.
29. Schwartz B, Kapellusch JM, Schrempf A, Probst K, Haller M, Baca A (2018) Effect of alternating postures on cognitive performance for healthy people performing sedentary work. Ergonomics 61(6): 778-795.
30. Sharifnia SH, Haghdoust A, Ghorbani M, Haji HF, Nazari R, Hojati H, et al. (2010). The relationship of low back pain with psychosocial factors and psychological stress in nurses in Amol Hospitals. Knowledge and Health 4(4): 27-33.
31. Sohrabi MS, Babamiri M (2021) The Effectiveness of Ergonomics Training Program on Musculoskeletal Disorders, Job Stress, Quality of Work Life and Productivity in Office Workers: A Quasi-Randomized Control Trial, JOSE, DOI: 10.1080/10803548.2021.1918930.
32. Torbeyns T, Bailey S, Bos I, Meeusen R (2014) Active workstations to fight sedentary behaviour. Sports Med 44(9):1261-73. doi: 10.1007/s40279-014-0202-x.
33. Zeydabadi A, Askari J, Vakili M, Mirmohammadi SJ, Ghovveh MA, Mehrparvar AH (2019) The effect of industrial noise exposure on attention, reaction time, and memory. Int Arch Occup Environ Health 92(1): 111-116.
34. Zhang Z, Zhang B, Cao C, Chen W (2018) The effects of using an active workstation on executive function in Chinese college students. PLoS One13(6):e0197740.