THE EFFECT OF USING THE “20-8-2” PATTERN AT AN ACTIVE WORKSTATION ON COGNITIVE AND TASK PERFORMANCE

A Thesis

by

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Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

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December 2019

Major Subject: Safety Engineering

ABSTRACT

Currently, office workers spend most of their time sitting while in their work environment. This prolonged sitting can result in negative health effects reducing office workers` productivity. While standing-based workstations can offer a beneficial approach to reducing sedentary behavior, long-term standing can also result in negative health outcomes. To obtain the proper balance, Alan Hedge, Professor of Ergonomics at Cornell University, has recommended a working pattern in which every half hour individuals sit for 20 minutes, stand for 8 minutes, and move around for at least 2 minutes. Therefore, the purpose of this study is to determine the effect of using this "20-8-2" pattern at an active workstation on measures of cognition, attention, short-term memory, task performance, and productivity.

Two different experiment conditions wherein participants used the :20-8-2" pattern at both seated and active workstations were designed and tested by a within-group examination in order to compare an individual`s ability to perform batteries of cognitive and performance tests in each environment. At the seated workstation, participants sat during each of the test sections. At the active workstation, participants performed the "20-8-2" pattern, sitting for 20 minutes, standing for 8 minutes, and walking on a treadmill at 2.5 mph for 2 minutes. The experiment consisted of four sections that included two different test batteries, one performance test battery that measured productivity via three repetitive sections at the two different workstations, and a cognitive test battery that measured attention and short-term memory via three sections completed while subjects were in sitting position. Participants` energy expenditure was also tracked during all test sessions.

The results show that using the “20-8-2” pattern at an active workstation did not impair task or cognitive performance. However, using the “20-8-2” pattern over time did seem to improve task performance. Also, the “20-8-2” pattern at the active workstation did not appear to decrease attention span or short-term memory, or cause an increase in stress or musculoskeletal discomfort. In addition, this study found significant differences in energy expenditure between subjects using the “20-8-2” pattern at the active workstation versus completing the tests at the seated workstation. This study provides evidence that using an active workstation may be beneficial as a means of increasing total energy expenditure and decreasing sedentary time.

DEDICATION

To the world. I hope this helps.

ACKNOWLEDGEMENTS

It is a great pleasure to acknowledge all those who help to make this dissertation possible. First, I would like to take this opportunity to express my sincere gratitude to my co-advisor and committee member Dr. Mark E Benden. The work presented in this dissertation would have never been initiated without the help, support, and guidance. Dr. Benden, I cannot thank you enough for not only taking me on as a graduate student halfway through my program, but also adopting me into your own family. It was difficult to be far away from my family, but without hesitation, Dr. Benden and his team provided the family feeling I needed at Texas A&M University School of Public Health. Thank you, for taking a chance on me to work with you, for your precious support, knowledge about science, endless patience, and constant encouragement and support throughout this research. It is an honor and a privilege to be his student, and he will always be regarded as my mentor and role model.

I also would like to extend my gratitude to my advisor and committee member Dr. Thomas K Ferris. Dr. Ferris provided encouragement and excellent research guidance through my master study. He always supported me with tremendous help and guidance since the first day I started my research. I am very thankful for his positive attitude and all of the contribution along the way. I would like give thanks to the other member of my committee, Dr. Ranjana K Mehta.

In addition, I would like to express my deepest appreciation to Dr. Joohyun Rhee and lovely Grace Anderson for their help, feedback, and support throughout the laboratory experiment.

Also, I would like to thank Turkish Ministry of National Education and Turkish Petroleum Corporation for their financial and emotional support during my master degree.

A special thanks go to my dear friends who has been generous and helpful when I needed it most. I had the pleasure of knowing and forming special relationship with all of them in this journey.

Last but not least, I would like to thank my parents, Halil and Perihan, and my brothers, Gokhan, Gokberk and his wife Ezgi. None of these accomplishments would have been possible without their sacrifices. Especially, I'm extremely grateful to my little brother Gokhan for always being my person, for always being there for me no matter what, and for his undying encouragement supporting me in whatever crazy path I choose to do next.

CONTRIBUTORS AND FUNDING SOURCES

This work was supervised by a dissertation committee consisting of (1) Dr. Thomas K Ferris (advisor), Associate Professor in the Department of Industrial and Systems Engineering at Texas A&M University and director of the Human Factors & Cognitive Systems Laboratory, (2) Dr. Mark E Benden (co-advisor), Associate Professor and Department Head for the Department of Environmental and Occupational Health at the Texas A&M School of Public Health, and director of the Ergonomics Center, (3) Dr. Ranjana K Mehta (committee member), Associate Professor in the Department of Industrial and Systems Engineering and the director of the Neuro Ergonomics Laboratory.

All the work conducted for the dissertation was completed by the student independently.

Graduate study was supported by dissertation research project grants from Texas A&M University Ergonomics Center.

NOMENCLATURE

ANOVA	Analysis of Variance
BMI	Body Mass Index
BMR	Basal Metabolic Rate
FAAWQ	Feasibility and Acceptability of an Active Workstation Questionnaire
GHIQ	General Health Information Questionnaire
HRPP	Human Research Protection Program
IRB	Institutional Review Board
MET	Metabolic Equivalents
OSPAQ	Occupational Sitting and Physical Activity Questionnaire
PEBL	Psychological Experiment Building Language
RT	Response Time
SPSS	Statistical Package for the Social Sciences
TAMU	Texas A&M University
WHO	World Health Organization
WS	Workstation

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1. INTRODUCTION

1.1 Introduction

Nowadays, people spend most of their time in work environment, and their productivity increases as long as they are happy in the workplace. For this reason, the importance of having a healthy and safe environment in the workplaces increases day by day. While providing healthy and safe workplace to office workers, the most important science to be utilized is “Ergonomics” which aims to ensure the harmony of the physical environment to the employee. Therefore; in the study conducted within the scope of this thesis, ergonomic elements have been given priority.

The increasing awareness of ergonomics all over the world accelerates the efforts to transform the office environment into healthy places and the tendency to create ergonomic workstation is becoming widespread. The design of workstation, which offer employees a more flexible, dynamic and active office environment, has become an important part of business life. Therefore, recent studies show that many different workstations have been developed to provide an active workplace for office workers (i.e., standing tables, treadmill tables and bicycle workstations).

As a result of the increase in the importance of the active office environment, standing desk that reduce the amount of time office worker spend sitting have become popular. However, long-term standing at the office may also have negative effects on office workers. To balance the time spent sitting and standing at the office, an active workstation could be used with a sit-stand-move pattern.

1.2 Literature Review

1.2.1 The Effects of Prolonged Sitting on Human Health

In the modern world, people sit for much longer duration than ever before. Regardless of whether or not an employee works at a desk, they are likely to spend a great deal of time sitting throughout the day. One of the issues about that the World Health Organization (WHO) strongly warns is that this general increase in sitting time leads to a more sedentary lifestyle. Recent studies have shown that this inactivity and prolonged sitting can harm people`s health [1-3]. Incorrect and uneven body posture can add to the problem, increasing the risk of cardiovascular disease, cancer, diabetes, obesity, metabolic issues, musculoskeletal complications, and other important health problems [4-7].

A sedentary lifestyle increases office workers` daily sitting time and decreases movement. Sitting less and standing more throughout the day is one of the most important ways of ensuring a healthy and high-quality life. However, according to some research, prolonged standing can also cause health problems [8-10]. If individuals do not engage in motion during the day, these health issues can increase, regardless of whether their work is completed solely by sitting or standing. Therefore, people should try to establish a balance between sitting, standing, and physical movement in their daily lives.

1.2.2 A Healthy Life Culture Begins at the Office

Offices that encourage mobility protect employees from the harm that can result from an immobile life. Office workers who apply a sitting-standing-moving strategy tend to be more efficient and healthier [11-12]. In addition, an active office life can lead to an increase in physical health and decrease in health expenditures for employees and employers, respectively, as well as improve the desirability of a workplace to potential employees. Furthermore, such an atmosphere strengthens relationships and interactions among the employees, increases corporate loyalty, establishes a stronger organizational structure, and helps to increase workers` energy and motivation.

1.2.3 The Key to Healthy Work: Sit-Stand-Move

Many studies regarding sit-stand workstations have shown that standing for certain workhours reduces discomfort and the likelihood of critical health problems among office workers [13-15]. Yet using adjustable desks at the office, while helpful, may not be enough. Alan Hedge, Professor of Ergonomics at Cornell University, recommend that people sit for 20 minutes at a time, stand for 8 minutes, and move for 2 minutes [16]. The purpose of this principle is to balance movement and minimize the negative consequences of employees` immobility, causing them to, stand for at least 2 total hours of every 7.5-hour work day, 16 sit-to-stand transitions, and walk for a total of 30 minutes at a slow pace. This pattern, with small breaks during the day and short walks around the office, is beneficial to office workers` health, improving their performance and allowing them to concentrate on their work more easily by giving their brains short moments of rest [17-18].

1.2.4 The Effects of Prolonged Sitting on the Brain

The results of studies investigating the effects of prolonged sitting on cognitive functions have varied [19 - 24]. While some laboratory research has supported the idea that sitting throughout the day has a negative impact on cognitive tasks as compared to periodic sitting [19-21], some researchers have not supported this idea [22-23]. Other scholars who observed people over a number of years suggested that there is a relationship between prolonged sitting and impaired cognitive function [24-25]. Nevertheless, as previous studies have used a number of different measurement methods, it is difficult to base a comprehensive conclusion upon them.

In some cases, sitting creates signals of rest in the brain; standing results in the opposite. Generally, when human sit to work, only the brain and hands are in use. When humans standing to work, the whole body is synchronized with the brain. It is thought that simple operational functions such as reading, writing, clicking on internet links, etc. become faster. Long-term standing can be physically exhausting. However, utilizing short-term standing as a way of working makes people faster and better focused. Consequently, they become more productive.

1.2.5 The Effects of an Active Workstation on the Brain

According to the currently available evidence, shortening the time spent sitting slows the decline of cognitive function rather than increases it. Despite the lack of studies examining the relationship between cognitive health and sitting, it is generally recommended to shorten sitting time in order to prevent the consequences of poor glucose control [26]. Considering the likely improvement in glucose control, it is commonly recommended to reduce sitting especially after eating. Several studies have also shown that walking at a mild pace instead of sitting after eating improves glucose control [26, 27].

When people engage in continuous work, they consume the brain`s resources. This is manifested by mental fatigue and low energy, making individual much more sensitive to stimuli. As a result, they increase pressure on their consciousness to sharpen their attention. Breaking the work cycle helps people to collect their energy, improves control and decision-making power, and increases productivity. People should take small breaks during the work day to protect and maximize their attention and cognitive function. In particular, mild physical activity and walking noticeably increases human perception and the ability to learn.

1.3 Purpose of the Study

One of the most important problems faced by a majority of office workers is prolonged sitting time. As is commonly understood, prolonged sitting causes a number of health problems. According to experts, in order to minimize these problems and enjoy a healthy office lifestyle, the time spent sitting must be reduced. The positive effects of reducing sitting time on health can be explained by the provision of glucose control. However, the effects on cognitive function are as yet under-studied. Prolonged sitting has been found to affect cognitive function through its proven effect on long-term memory and the root cause dementia. Yet what is the effect of prolonged sitting on short-term memory and attention span? As compared to research conducted on the use of standing work stations, the effects of the sit-stand-walk transition on cognitive and task performance have yet to be fully explored and the effects of an active workstation (i.e., whether positive or negative) remain unclear. The present research analyzed whether a sit-stand-move process would affect task and cognitive performance as compared to uninterrupted sitting, as well as whether the use of an active work station might provide the improved conditions when considering simultaneous changes in energy expenditure. Therefore, the purpose of this study was to determine the effects of using the “20-8-2” pattern described above in conjunction with an active workstation on measures of cognition, attention, short-term memory, and task performance.

1.4 Research Questions

1. What are the effects of using an active workstation in an office environment on cognitive and task performance?
2. Does using the "20-8-2" pattern at an active workstation affect efficiency and task performance?
3. Does walking during short breaks instead of continuous sitting have any effect on cognitive and task performance?
4. What are the effects of standing instead of continuous sitting on focus when performing search tasks?
5. Does using the "20-8-2" pattern at an active workstation instead of prolonged sitting affect short-term memory and attention (i.e., cognitive performance)?
6. Is there any difference between working on active workstation and seated workstation in total energy expenditure?
7. Does energy expenditure change over time if the "20-8-2" pattern is used at an active rather than seated workstation?
8. Is the use of an active workstation and the "20-8-2" pattern feasible and acceptable for office workers?

2. METHODS

2.1 Participants

A convenience sample was obtained from Texas A&M University. All participants were employed in professional/academic roles or as full-time graduate students and identified their work as predominantly desk-based sitting; none had any prior exposure to sit-stand desks. Participant inclusion criteria were: being healthy (i.e., no acute or chronic diseases), aged 22 to 35 years, regularly working in a sedentary office environment, not having any experience with sit-stand desk workstations, regular computer use, knowing the English language, and consenting to participate. Exclusion criteria were: having any current or previous lower limb injuries, pre-hypertension and/or pre-diabetes, suffering from coronary artery disease, orthopedic limitations regarding performing physical activity, and color blindness or visual impairment that had not been corrected.

Table 2. 1 Participant Demographics

	Mean ± Standard Deviation	Min	Max
Age (years)	27.2 ± 3.6	22	35
Height (cm)	172 ± 10.48	157	187
Weight (kg)	72.5 ± 13.22	56	104
BMI (kg/m^2)	24.4 ± 2.9	18.3	31
BMR (kcal/hr)	69.75 ± 11.4	56.4	92.3

Fourteen participants (7 females and 7 males) participated in this study, with an average age of 27.2 years (SD = 3.6). Table 2.1, Participant demographics shows the participants' baseline characteristics. The average height was 172 cm (SD = 10.48) and weight was 72.5 kg (SD = 13.22). Body mass index (BMI) was calculated using the standard formula (i.e., [weight (kg) / height (cm^2)] x 10,000). In addition, Figure 2.1 illustrates a breakdown of the participants' educational backgrounds. The largest percentage of the sample group had completed master`s degrees. Basal Metabolic Rate (BMR) was calculated using the standard formula (i.e., [Women BMR = 655.0955 + 9.5634 x weight (kg) + 1.8496 x height (cm) – 4.6756 x age (years); Men BMR = 66.4730 + 13.7516 x weight (kg) + 5.0033 x height (cm) – 6.7550 x age (years)]).

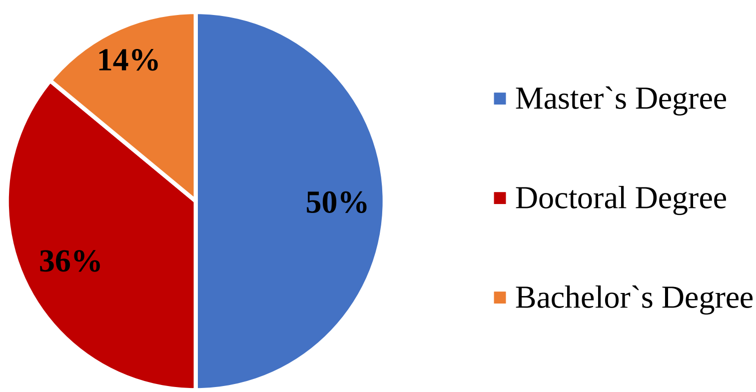

Figure 2. 1 Participants` Educational Backgrounds

2.2 Procedures

This research was approved by Texas A&M University Institutional Review Board (IRB) number 2019-0321D. The initial contact with potential participants was made via a bulk recruitment email (see Appendix A) sent to students at Texas A&M University. This email contained a participant information sheet (see Appendix B) that provided the details of the research, risks and benefits, ethics approval information and the time required to participate in the study. Participants were given 10 days to review the consent form and decide whether or not to participate. The investigator explained the information sheet and informed consent form to prospective participants, if necessary. All questions were answered and all concerns addressed. If the participant agreed to participate in the study and met all eligibility requirements, he or she was asked to sign the IRB approved informed consent form (see Appendix C) prior to beginning the study procedure in the laboratory at the Texas A&M Health Science Center School of Public Health.

2.3 Study Design

All participants gave their informed consent for inclusion before participating in the study. The study was conducted in the laboratory at the Texas A&M Health Science Center School of Public Health. Participants visited the laboratory for 2.5 hours per session, on two different experiment days. All data were collected during these visits to the laboratory. During the first visit, all participants completed a General Health Information Questionnaire (GHIQ) for the purpose of self-reporting their height, weight, age, gender, and education, and answering certain baseline questions about their overall health. In addition, they completed an Occupational Sitting and Physical Activity Questionnaire (OSPAQ) to determine how much time they spent sitting per workday, the number of days in a week they worked, and their weekly exercise days and hours. At the end of the second visit, all participants completed a Feasibility and Acceptability of Active Workstation Questionnaire (FAAWQ) to evaluate their experience with the "20-8-2" time regime (i.e., 20 minutes sitting, 8 minutes standing, 2 minutes walking) at an active workstation.

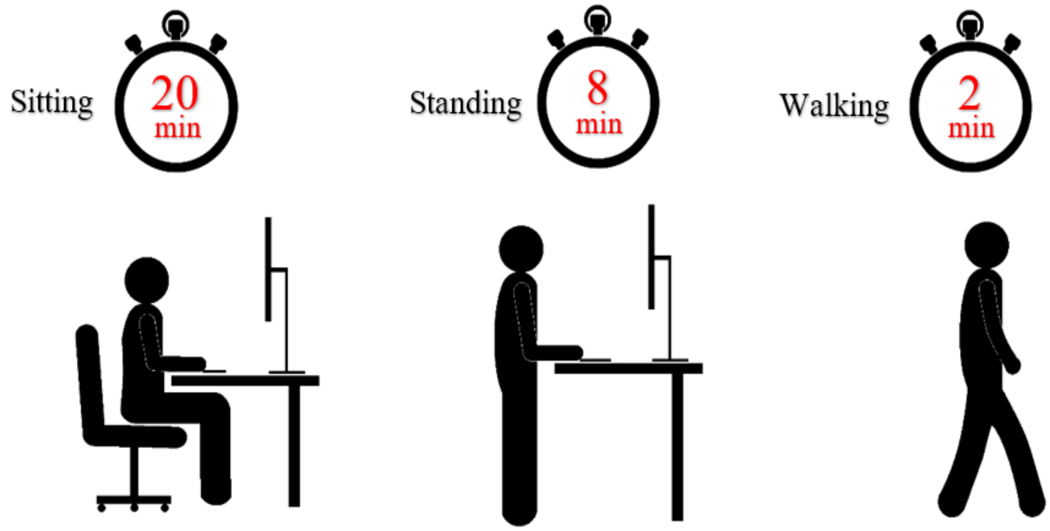

Figure 2. 2 The “20-8-2” Pattern

Two different experimental conditions, seated and active workstations at which participants used the “20-8-2” pattern (see Figure 2.2), were designed and tested for each participant. Table 2.2, in the experiment design, a within-group examination was conducted to compare participants` ability to complete performance and cognitive test under the two sets of test conditions. All participants completed the test batteries for the two different experiment conditions. Participants were tested at the same time of day on two days (with exactly seven days in between) in each of the two experiment conditions. Each participant was assessed with regards to their performance while in these experiment conditions. During each test session, the participant’s energy expenditure was tracked via a BodyMedia SenseWear armband.

Table 2. 2 Experiment Conditions and Sections

	Seated Workstation			Active Workstation ("20-8-2" Pattern)		
	Test Battery	**Position**	**Time (min)**	**Test Battery**	**Position**	**Time (min)**
Section 1	Performance Test Battery	Sitting	30	Performance Test Battery	Sitting Standing Walking	20 8 2
Section 2	Performance Test Battery	Sitting	30	Performance Test Battery	Sitting Standing Walking	20 8 2
Section 3	Performance Test Battery	Sitting	30	Performance Test Battery	Sitting Standing Walking	20 8 2
Section 4	Cognitive Test Battery	Sitting	20-30	Cognitive Test Battery	Sitting	20-30
Total Time			115±5			115±5

The experiment test battery took approximately 120 minutes. In the first experiment condition, participants were asked to sit during each section. During the seated workstation session, participants were asked to remain seated while performing the test battery (see Figure 2.3). They were free to use the restroom when needed, but no other activity was permitted. In the second experiment condition, participants performed the "20-8-2" pattern at an active workstation. They were asked to sit, stand, and walk on a treadmill for each section (see Figure 2.4). The active workstation used in this study was a sit-stand desk adjustable for either a sitting or standing height. The workstations were adjusted ergonomically to each participant.

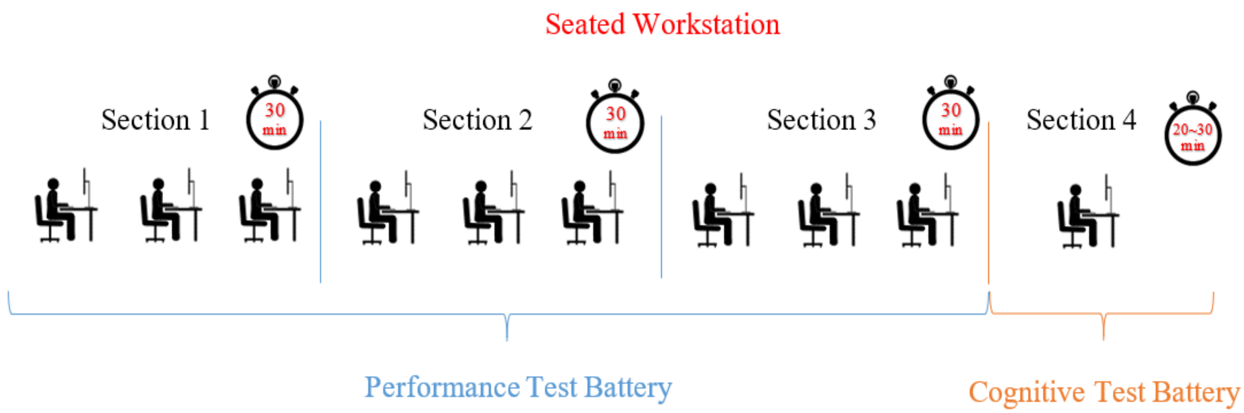

Figure 2. 3 Seated Workstation

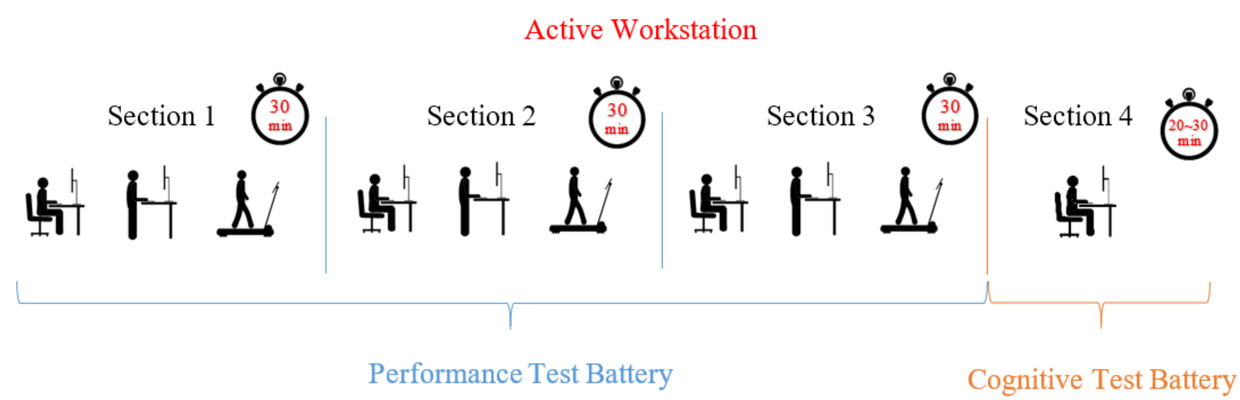

Figure 2. 4 Active Workstation

Participants completed two days of sessions under laboratory conditions. To minimize any practice-related testing effects, all participants were randomly assigned both conditions to complete the test battery. Both sessions were executed individually (one participant per session) in the same laboratory. The second session was executed exactly seven days after the first (i.e. if the first session was on a Tuesday, the second was on the following Tuesday). Each session began at 10:00 am or 2:00 pm to reduce fluctuations in individual performance due to the time of day. An outline of how the experiment days were scheduled can be found in Table 2.3. In addition, at the beginning of the first session, participants were familiarized with the performance and cognitive test batteries by the researcher explaining and demonstrating each task.

Table 2. 3 Experiment Schedule

Start Time	Starting with Seated Workstation	Starting with Active Workstation
10 am	3 Subjects	3 Subjects
2 pm	4 Subjects	4 Subjects

2.4 Test Batteries

Participants attended two experiment sessions in a quiet laboratory environment, each occurring at the same time of the day and spaced at a seven-day interval. On each experiment day, testing took approximately two hours (i.e., 120 minutes) to complete the session. The battery consisted of four sections that included two different test batteries, one performance and one cognitive. In the first three sections, participants completed the performance test battery while using the two different workstations (i.e., seated and active), followed by completing the cognitive test battery at a seated workstation. Participants were instructed to perform the test battery as quickly and accurately as possible. The performance and cognitive test batteries consisted of computerized tasks and tests designed in the Psychological Experiment Building Language (PEBL) (Version 2.1; available from http://pebl.sourceforge.net/) [28]. PEBL is an open-source psychology software package developed to run computer-based psychology experiments (see Figure 2.5). During each test battery, participants` reaction times and correct responses were recorded.

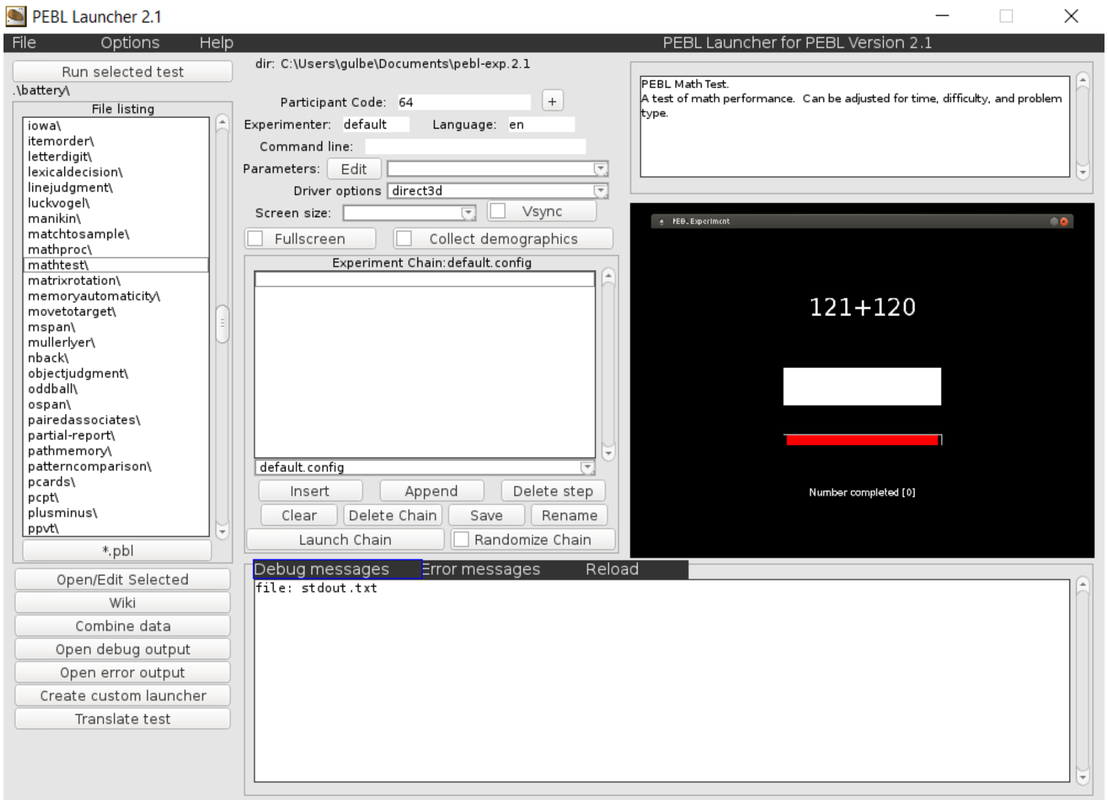

Figure 2. 5 Graphical User Interface of PEBL [28]

2.4.1 Performance Test Battery

In the first three sections, performances of work-related tasks - two standardized common office tasks (i.e., typing and math) and one search task (i.e., word search puzzle) - were assessed in two experiment conditions (i.e., seated and active workstation) using a repeated-measures design. During these task performance sections, each participant performed three different tasks in two different experiment conditions. All sections contained the same tasks in the same order; however, the content of each task was different. At beginning of the section, the participant was asked to type a passage for 10 minutes, solve math problems for 10 minutes, and do a word search puzzle for 8 minutes in a sitting position at the seated workstation. The participant took a 2-minute break before completing the next section (see Figure 2.6). At the active workstation, the participant was asked to type a passage for 10 minutes and solve math problems for 10 minutes in a sitting position. Then, participants completed a word search puzzle for 8 minutes in a standing position at the active workstation. Next, each participant walked for 2 minutes on a treadmill (see Figure 2.7). Each section of the performance test battery took 30 minutes; the three sections were timed to be finished in approximately 1.5 hours (see Table 2.4).

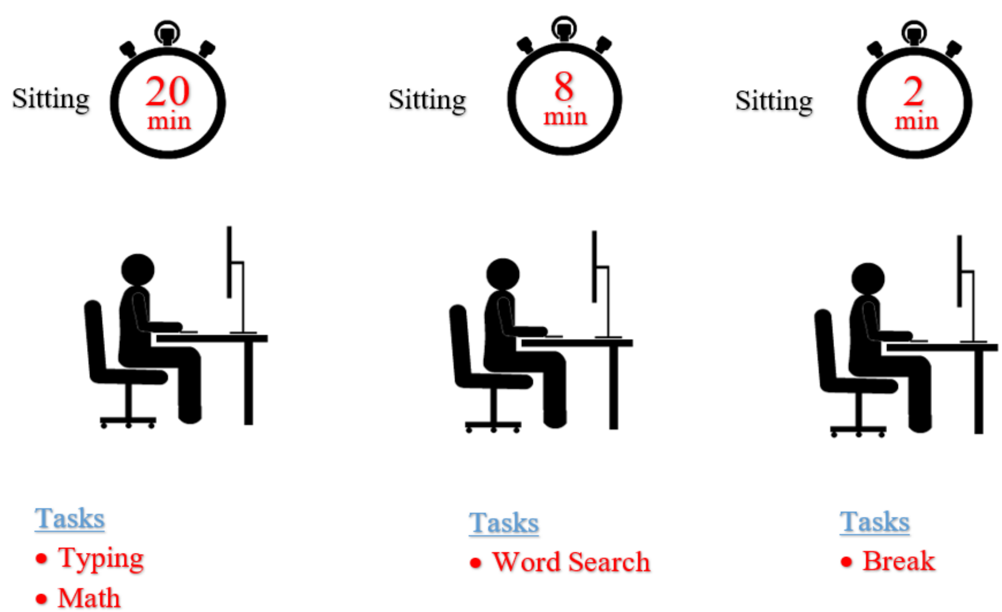

Figure 2. 6 Performance Test Battery at the Seated Workstation

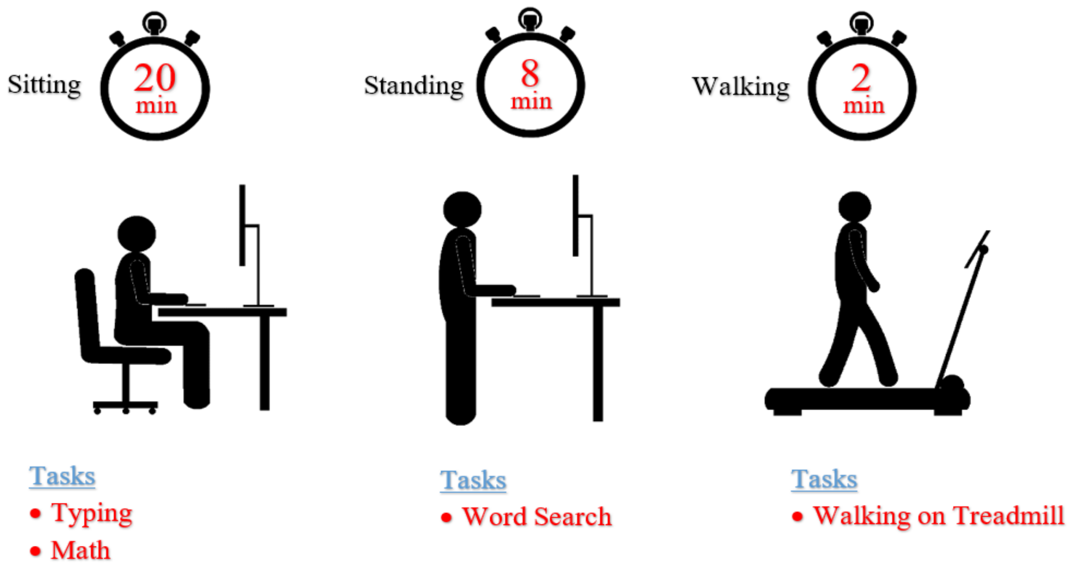

Figure 2. 7 Performance Test Battery at the Active Workstation

Table 2. 4 Performance Test Battery

Performance Test Battery (Section 1-3)					
Seated Workstation			**Active Workstation (“20-8-2”)**		
Task	**Position**	**Time (min)**	**Task**	**Position**	**Time (min)**
Typing	Sitting	10	Typing	Sitting	10
Math	Sitting	10	Math	Sitting	10
Word Search	Sitting	8	Word Search	Standing	8
Break	Sitting	2	Break (Walking on Treadmill)	Walking	2
Total Time		30±1			30±1

2.4.1.1 The Typing Task

The goal of the typing task was to measure the motor skills of the participants. The task was performed on a computer with the help of the PEBL program. In this task, participants typed texts. Three different texts, each composed of nonsense word groups of an equal level of difficulty, were used for the three sections of the performance test battery (see Appendix D). The goal was for participants to rewrite the given text as quickly and accurately as possible by following it on the computer screen. The text was shown at the top of the screen, along with an indicator; the text typed by the participant appeared at the bottom of the screen. Backspace was disabled during typing. As the participants followed the indicator, a green light was illuminated as long as the text was typed correctly. If a participant made a mistake (e.g., typed an incorrect or incomplete letter), the cursor turned red and the error could not be corrected.

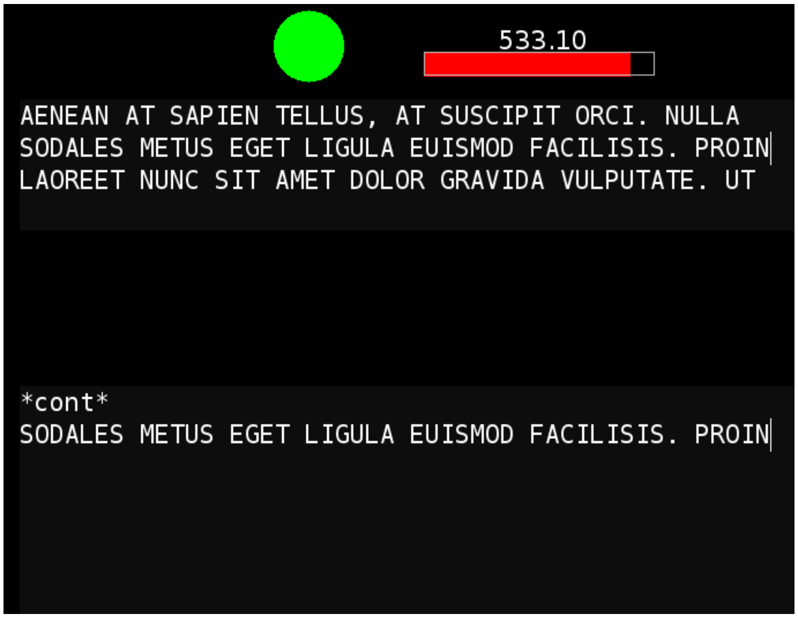

Figure 2. 8 Screenshot of the Typing Test [28]

The typing task for each test section was set at 10 minutes. Above the given text was a countdown (beginning at 600 seconds) and a red bar indicating the time remaining. A screenshot of the task obtained from PEBL is shown in Figure 2.8.

2.4.1.2 The Math Task

The math task required participants to answer simple math problems using their mathematical skills and problem-solving abilities. It was completed on a computer via the PEBL program. In this task, participants were given a series of algebraic math problems (i.e., multiplication, addition, subtraction, and division) that involved two numbers. Participants were asked to solve each problem in their head. There was a red bar showing the time remaining under each problem. The math test consisted of seven blocks of 80-second-periods. Dividing test into blocks provided participants with recovery times during the passing between each block. The math task for each test section was set at 10 minutes. A screenshot of the applied task described in the text and obtained from the PEBL program is shown in Figure 2.9.

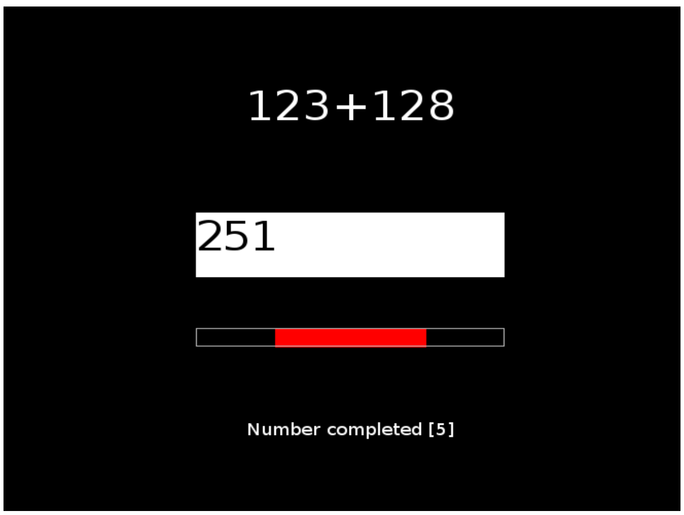

Figure 2. 9 Screenshot of the Math Test [28]

2.4.1.3 The Word Search Task

The word search task was completed on a computer via a word search puzzle website (available from http://word-search-puzzles.appspot.com/) [29]. The word search task was comprised of a word game consisting of the letters of words placed on a grid in a rectangular shape (14 x 16). The objective of this task was to find and mark all of the hidden words inside the box as quickly as possible. The target words could be placed horizontally, vertically, or diagonally. The list of the hidden words was provided on the side of the screen. Participant used their attention to detail and short-term memory to find the words. Above the grid, there was a timer showing the time remaining to complete the puzzle. The word search task for each test section was set at 8 minutes. A screenshot of the applied task described in the text is shown in Figure 2.10.

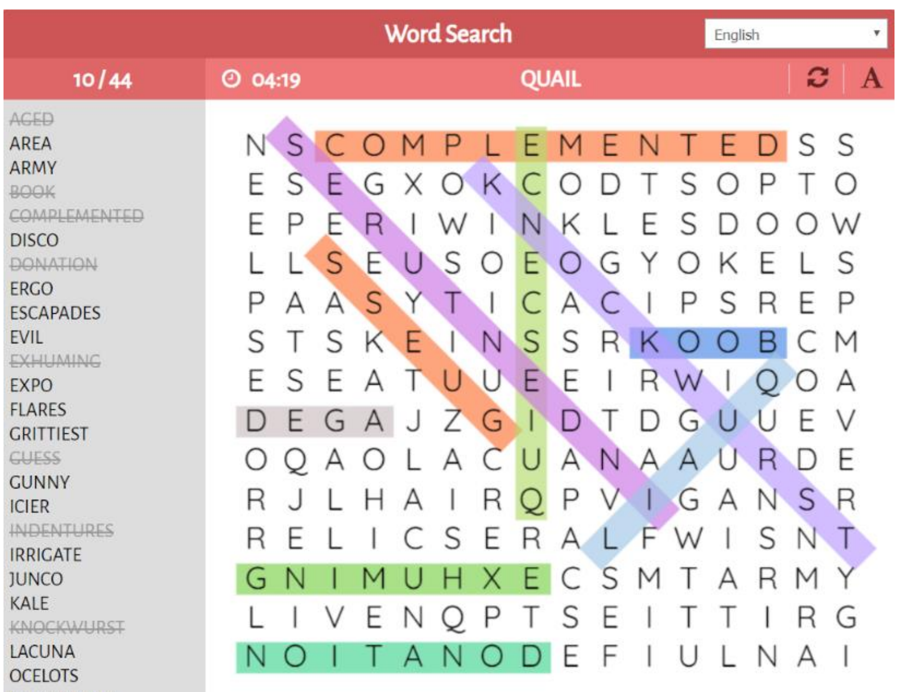

Figure 2. 10 Screenshot of the Word Search Puzzle [29]

2.4.2 Cognitive Test Battery

After completing the first three sections, participants performed the cognitive test battery in a sitting position in the two experiment conditions (i.e., at seated and active workstations). This fourth section, the cognitive test battery, was comprised of five cognitive tests: the Corsi block, the Stenberg memory, the digit span, the Mackworth clock, the Stroop tests. The cognitive tests were selected from previous research conducted to measure short-term memory, working memory, selective attention, sustained attention, motor processing speed, and response inhibition. All cognitive tests were completed on the computer with the help of the PEBL software. The duration of the cognitive test battery depended each participant`s performance and ranged between 20 and 30 minutes.

Table 2. 5 Cognitive Test Battery

Cognitive Test Battery (Section 4)			
Seated & Active Workstations (both Seated Position)			
Position	**Time (min)**	**Test**	**Cognitive Function**
Sitting	20-30	Corsi Block Test Stenberg Memory Test Digit Span Test Mackworth Clock Test Stroop Test	Visuo-Spatial Short-Term and Working Memory Short-Term Memory Working Memory and Short-Term Memory Long-Term Vigilance Attention Selective Attention and Cognitive Flexibility

2.4.2.1 The Corsi Block Test

The Corsi block test is a short-term visual working-memory test that uses blocks to present an image and asks the test taker to repeat the sequence. In the present research, the Corsi block test was used to measure participants` ability to remember a sequence of locations on a computer screen. Each participant was presented with nine blue squares on a screen. In each trial, the squares were lit up one at a time in a sequence. The test taker was then asked to remember that sequence. When the sequence was finished, participants clicked on each square in the same order as the block were presented. Each test began with a sequence of three squares, and participants were given two tries for each sequence length. The sequence length was increased by one square when the participant correctly mimicked the sequence in one of their two attempts. A screenshot of the applied task obtained from PEBL software is shown in Figure 2.11.

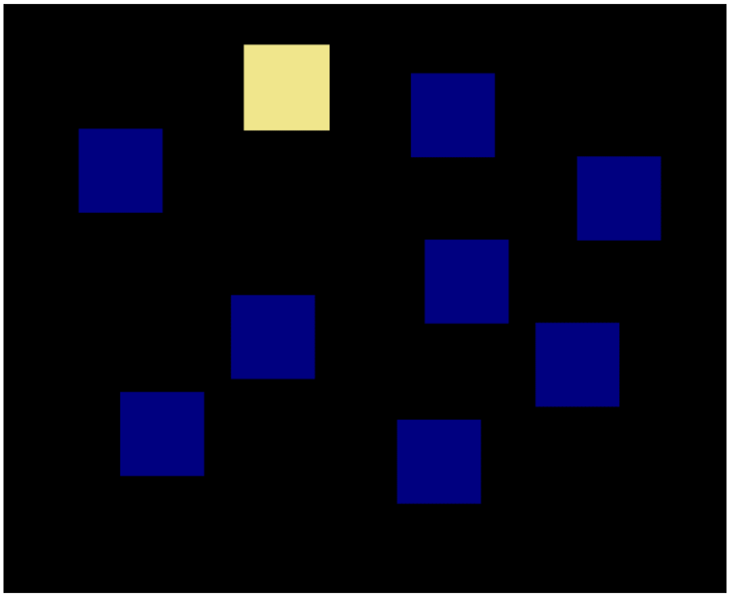

Figure 2. 11 Screenshot of the Corsi Block Test [28]

2.4.2.2 The Sternberg Memory Test

The Sternberg memory test is a short-term memory test involving the presentation of a list of letters that test takers are asked to memorize. Participants in the present research were presented with a list of random letters of the alphabet, B, C, D, F, G, H, J, K, L, M, N, Q, P, R, S, T, V, W, and Z. In this test, participants were shown and then asked to memorize a short list of these letters, such as NG, PHVR, or VHGMHC. Once a letter set was removed from the screen, a single letter was presented on the screen and the test taker was asked to indicate whether the letter was "present" or "absent" in the short list as quickly as possible. A screenshot of the applied task obtained from PEBL software is shown in Figure 2.12.

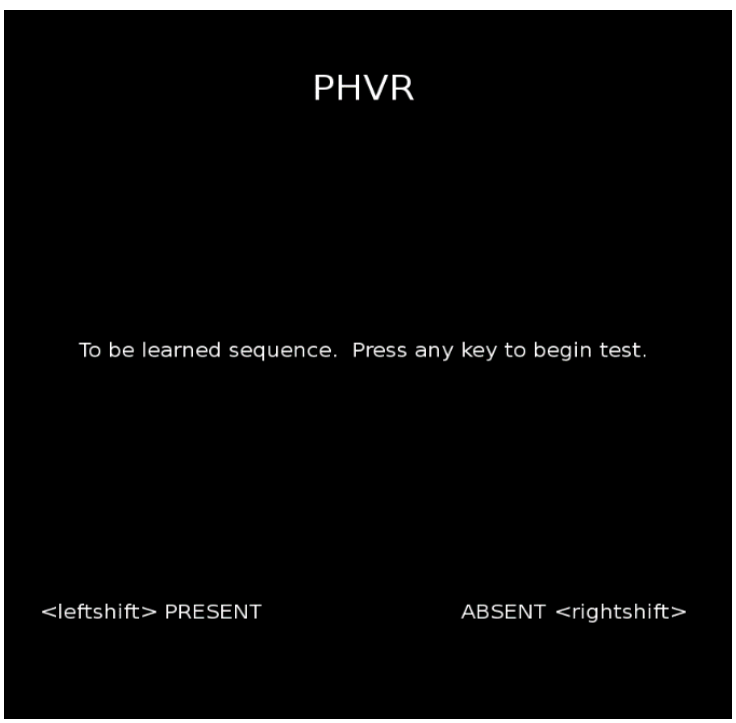

Figure 2. 12 Screenshot of the Sternberg Memory Test [28]

2.4.2.3 The Digit Span Test

In the digit span test, both working memory (in the backward digit span) and short-term memory (in the forward digit span) are tested. Participants were asked to view on a computer screen a sequence of digits presented one at a time. Each digit occurred only once in a list. Participants were then asked to type the list of digits exactly in the order they saw them on the screen. If they made a mistake, they were allowed use the backspace to make corrections. The test began by presenting a list of three digits; two different lists of each length were presented per round. If a participant correctly recalled one out of the two lists, they moved on to the next longest list length. The was no time limit. A screenshot of the applied task obtained from PEBL software is shown in Figure 2.13.

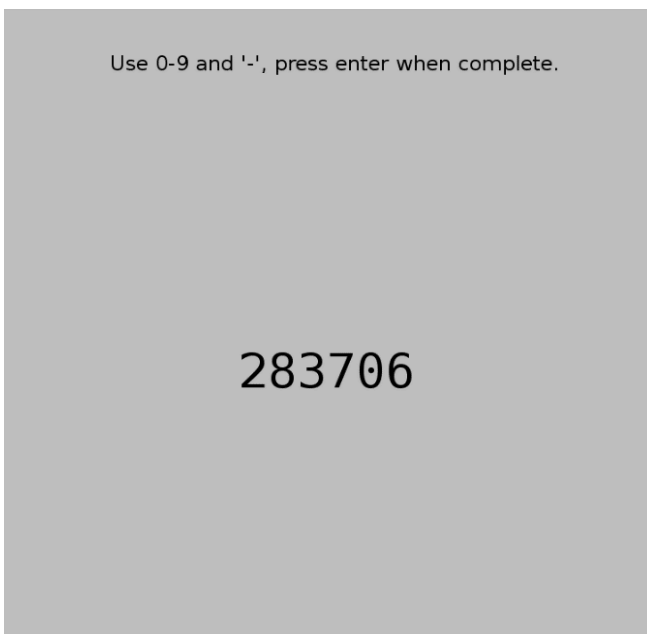

Figure 2. 13 Screenshot of the Digit Span Test [28]

2.4.2.4 The Mackworth Clock Test

The Mackworth clock is a device used in the field of experimental psychology to study the effects of long-term vigilance on the detection of signals. It was originally created by Norman Mackworth as a simulation of long-term monitoring by radar operators during World War II. The device has a large black pointer on a circular background (like a clock). The signal moves in short jumps every second, similar to the second hand of an analog clock. At infrequent and irregular intervals, the signal makes a double jump, (e.g. 12 times every 30 seconds). The task is to press a button when the double jumps occur. The participants in the present research were asked to watch the hand as it moved in a clockwise direction. When the signal jumped more than what was normal, the participant immediately pressed the space bar. A screenshot of the applied task obtained from the PEBL software is shown in Figure 2.14.

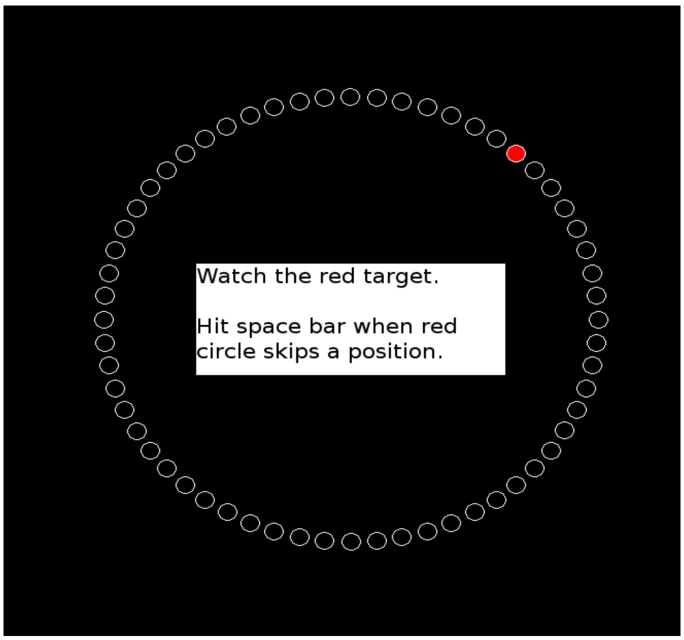

Figure 2. 14 Screenshot of the Mackworth Clock Test [28]

2.4.2.5 The Stroop Test

The Stroop test is used to measure selective attention and response inhibition. Participants were tested with regards to how well they could read the words and recognize the colors appearing on a computer screen. Participants were shown a series of words written on different colored backgrounds. The test was divided into three parts. In the first, which measured neutral reaction time, participants were shown X's appearing in yellow, red, blue, or green font, and were asked to respond by pushing the corresponding button on a keyboard. In the second part, the words "yellow", "red", "blue" and "green" were shown in colors that matched those described by the words and those that did not. Participants were asked to push the button corresponding to the color in which the words were displayed.

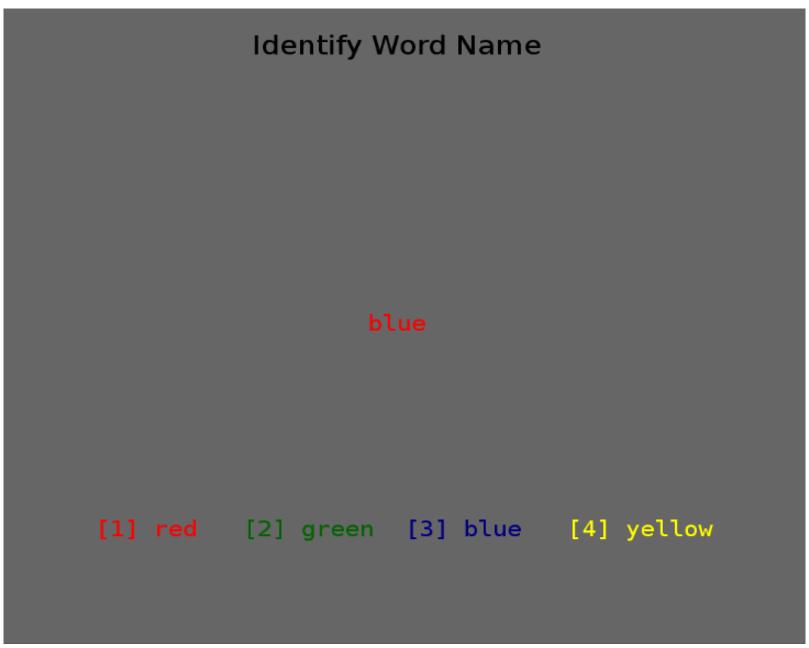

Figure 2. 15 Screenshot of the Stroop Test [28]

In the third part, the same words were shown in matching and non-matching colors, but this time the participants were asked to push the button corresponding to the word displayed on the screen (rather than color in which it was written). A screenshot of the applied task obtained from PEBL is shown in Figure 2.15.

2.5 Questionnaires

At the beginning of the first session, demographic information was obtained via GHIQ (see Appendix E). Participants reported their gender, age, native language, education, height, weight, smoking habits, alcohol usage, and general health (i.e., whether or not they had any chronic or acute diseases, any current or previous lower limb injuries, pre-hypertension and/or pre-diabetes, high cholesterol, coronary artery disease, orthopedic limitation on performing physical activity, color blindness or visual impairment that had not been corrected, or any anxiety and/or depression symptoms).

In addition to GHIQ, participants were asked to fill out the OSPAQ (see Appendix F), in order to obtain information about their occupational and daily activities. The questionnaire was composed of questions from the International Physical Activity Questionnaire [30] and the Occupational Sitting and Physical Activity Questionnaire [31]. This questionnaire was used to estimate the physical activity and sedentary time of each participant. Participants were asked to report their workhours and workdays per week; percentages of time spent sitting, standing, walking, and engaging in heavy labor and/or physically demanding tasks on a typical workday, maximum hours spent sitting at work; frequency of break times while working; total time spent sitting per day; daily sleeping hours; and time spent on physical activities per week.

After their sessions, participants were asked to complete the FAAWQ (see Appendix G) and describe their experience with the "20-8-2" time regime at the active workstation. The first part of the questionnaire asked participants to rate their overall experience with the active workstation, compare their ability to work at an active workstation to a regular workstation, and evaluate the "20-8-2" pattern as conducted at an active workstation. Responses were offered on a scale from worst (1) to best (10). The second part of the questionnaire consisted of 18 questions that were answered on a five-point Likert-scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree), These responses were used to assess participants' attitudes regarding the use of an active workstation and the "20-8-2" pattern in a work environment, as well as their feelings regarding their potential use in their work and/or daily lives.

2.6 Equipment and Measurements

The experiment space used in this study was a laboratory room at the Texas A&M University School of Public Health. The testing environment was controlled and remained consistent under all conditions. The simulated office environment consisted of a quiet room with ergonomic equipment that allowed for continuous performance from the participants.

Two different experimental conditions and one workstation were used in this study. A height-adjustable desk (LINAK Height Adjustable Electric Sit-Stand Desk, Model DPF1C) was used for both experiment conditions (see Figure 2.16). The first condition was a seated workstation with a height-adjustable desk and standard office chair (Herman Miller Adjustable Office Chair, Model Aeron). The second was an active workstation that consisted of a height-adjusted desk (which electronically adjusted to either a sitting or standing height), standard office chair, and treadmill (LifeSpan Treadmill, Model TR800-DT3). At the active workstation, participants were asked to sit, stand, and walk in the “20-8-2” pattern for each section of the test. The treadmill was placed next to the height-adjustable desk and standard office chair. In the standing condition, the chair was removed and the participant directed to stand in front of the desk. In the walking condition, participants left the height-adjustable desk and chair and walked on the treadmill. The treadmill was set at a slow speed (i.e., 2.5 mph) to encourage an, easy and healthy walking pace; all participants walked at the same speed. The workstation height was adjusted in each condition to an ergonomically correct position for each participant (i.e., 90° elbow flexion and 0° wrist extension/flexion when typing on the keyboard).

Figure 2. 16 Seated and Active Workstations

The electronical adjustable sit-stand desk provided participants with a large workspace, and was used for both the training and testing sessions. To perform the battery of cognitive and performance tests, the height-adjustable desk was furnished with a keyboard, mouse, and adjustable screen (see Figure 2.17). Prior to the measurements, working heights for the sitting and standing desks (both screen and desk), as well as for the office chair and hardware properties (e.g., keyboard distance, screen height, screen angle) were adjusted by the researcher according to ergonomic recommendations (i.e., elbow height for keyboard home row screen height set to top of monitor at eye height and posture generally upright in seated and standing position). Temperature and humidity (23.2 ˚C and 55% RH) were controlled and kept identical for both experiment conditions and sessions.

Figure 2. 17 Experiment Hardware

Energy expenditure (kcal/hour) was measured using a BodyMedia SenseWear armband (see Figure 2.18). BodyMedia SenseWear Armbands usage were used during to experiment hours while participants were present at the workstation, starting at the beginning of the session and ending with the session's completion. The armband was worn on the back of the upper left arm. To calibrate the armband for each participant, the information collected by the general health information questionnaire (including self-reported measures of year of birth, height, weight, dominant hand, and smoking habits) was used.

Figure 2. 18 BodyMedia SenseWear Armband

The armband provided energy expenditure data for each participant. The SenseWear software provides a variety of measurements (total energy expenditure, average metabolic equivalent (MET), active energy expenditure, physical activity duration, and number of steps, among others). Screenshots of the outputs obtained from the SenseWear software (Version 8.1; available from https://bodymedia-sensewear.software.informer.com/) are shown in Figures 2.19 and 2.20 [32].

Figure 2. 19 SenseWear Software Result for the Active Workstation [32]

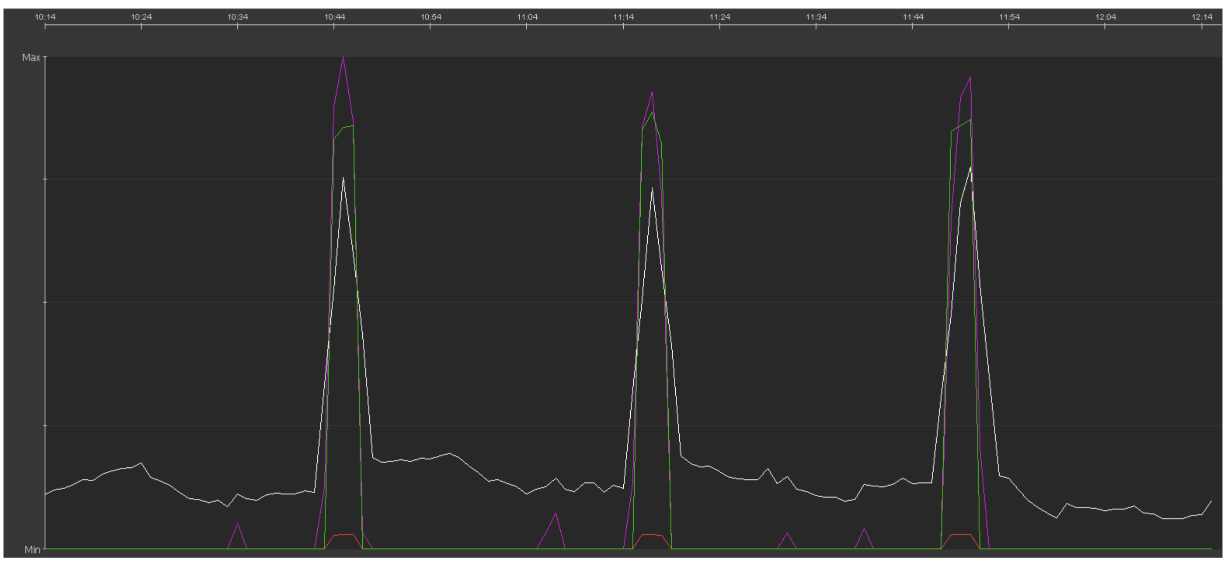

Figure 2. 20 SenseWear Software Graphical Result for Active Workstation [32] (white line: energy expenditure; red line: distance; green line: speed; purple line: step)

2.7 Statistical Analysis

All statistical analyses were completed using IBM SPSS (Statistical Package for the Social Sciences) Software (Version 25.0; IBM Corp., Armonk, NY, USA). Descriptive statistics for the data and, statistical test results were then calculated. This research was conducted via a within-subjects design and examined 14 participants. Since two different batteries of tests were used, two types data were collected. In the performance test battery, the data were collected from all subjects during three repetitive sections and under specific conditions. These were kept the same for each condition, and collectively termed section-oriented data. In the cognitive test battery, the data were collected from all subjects under both sets of conditions. The resulting information was collectively termed condition-oriented data. The Shapiro-Wilk test was used to determine whether the data were normally distributed and whether or not the collected data had a normal distribution.

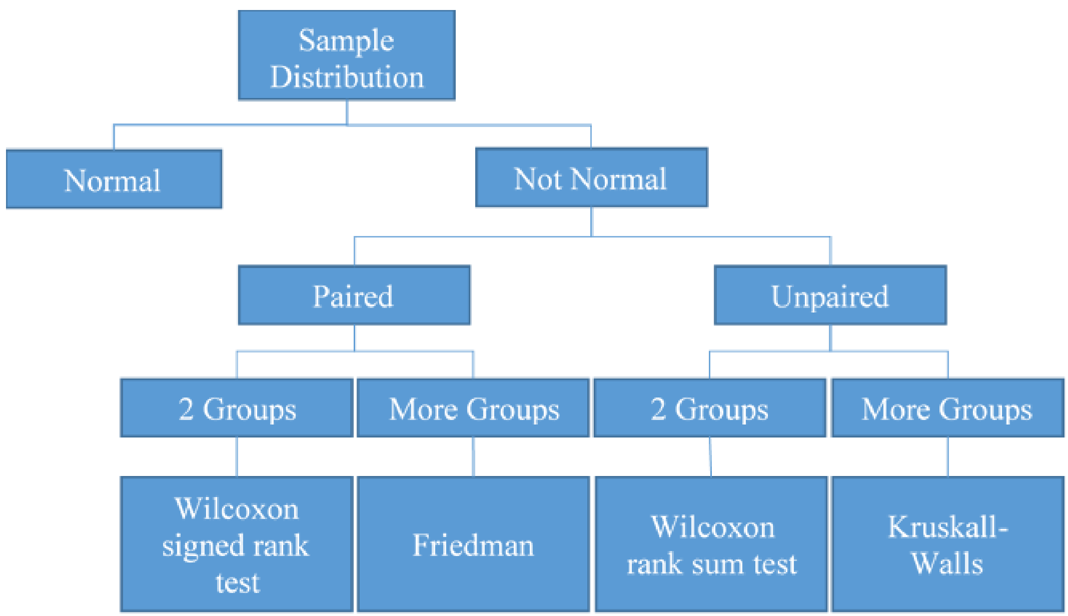

Figure 2. 21 Statistical Method Selection Chart [33]

This research used ordinal data collected from a dependent within-subjects (paired) sample. Since the sample size (n=14) was less than 30 and the data not normally distributed (i.e., non-parametric), the Wilcoxon signed rank test and Friedman ANOVA by ranks test were used (see Figure 2.21) [33]. The Wilcoxon signed rank test is a non-parametric statistical test used to compare two related or repeated measurements for a within-group analysis, in order to assess whether the mean ranks differ. The Friedman ANOVA, an extension of the Wilcoxon signed rank test, is used for data from a within-group study with three or more repeated measurements that do not have normal distribution.

For the questionnaire data, participants` responses were used to calculate mean scores. The standard deviations of questions were calculated per the questions in the questionnaires. These variables were used to analyze similarities and differences among participants` profiles before using the active workstation, and their ideas after using the active workstation and "20-8-2' pattern. For the performance test battery, section-oriented data were used for a Friedman test to determine differences among the three sections with regards to the seated and active workstations. Also, a Wilcoxon signed rank test was performed for each workstation to compare the average performance task scores, which were calculated based on condition-oriented data. For the cognitive test battery, a Wilcoxon signed rank test was performed to compare the cognitive performance test scores by seated and active workstations. To determine the differences in energy expenditure among the three sections for both experimental conditions (i.e., seated and active workstation), a Friedman test was used. A Wilcoxon signed rank test was applied to determine the mean differences in total energy expenditure between the seated and active workstations. Common values of a level of significance (α) of 0.05 were used for all analyses.

3. RESULTS

3.1 Performance Test Battery

The performance test battery was used to verify that the measures for identifying the differences in task performance for the two different workstations were both reliable and valid. This battery of tests presented work-related performance as outcome measures for productivity. Three different types of work-related performance tasks (i.e., typing, math, and word searching) were assessed. In order to assess performance task battery, separate scores were calculated for each task. Friedman and Wilcoxon signed rank tests were used for the statistical analysis because normality conditions were not satisfied for the within-group examination.

3.1.1 The Typing Task

For the typing task in the performance test battery, continuous data were collected in units of words per minute, characters per minute, tokens per minute, completed words from the text, and accuracy (from the percentage of typing errors per text) for all three sections and each condition. Individual typing task scores were determined by the correct characters per minute and calculated by multiplying the accuracy by the number of characters per minute (i.e., Character per Minute x Accuracy). The moreover, average typing scores per person were calculated by taking the average of the three sections for each condition. This condition-oriented data for the seated (blue block) and active (red block) workstation are given in Figure 3.1.

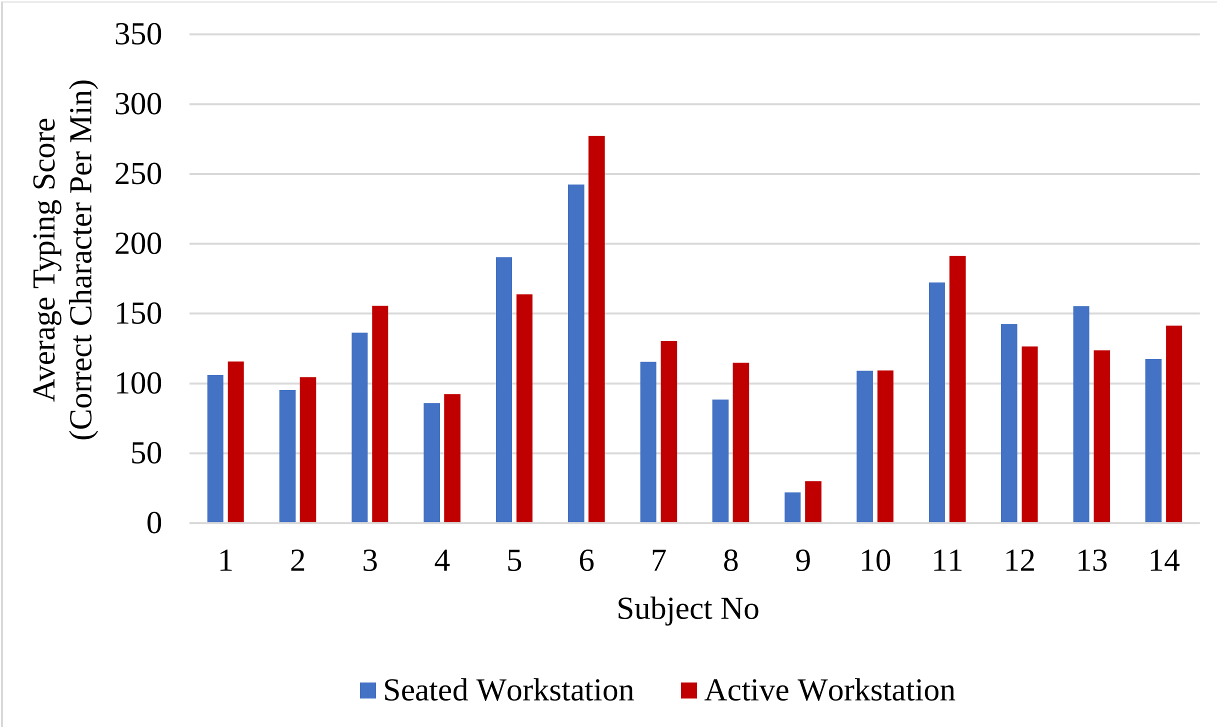

Figure 3. 1 Average Typing Scores for Different Workstations

The descriptive statistics for the average typing scores in each condition are presented in Table 3.1. These data were tested via Wilcoxon signed rank test to analyze whether there were significant differences. The results of this statistical test, including Z-score and p-value, are shown in Table 3.2.

Table 3. 1 Descriptive Statistics for Average Typing Scores by Condition

	N	Mean	Std. Deviation	Min	Max
Seated Workstation Average Typing Score	14	127.1307	53.1422	22.0978	242.5088
Active Workstation Average Typing Score	14	134.0486	55.5674	30.0637	277.3591

Table 3. 2 Statistical Result for Typing Scores (Wilcoxon Signed Rank Test)

Test Statistics[a]	Active WS Average Typing Score - Seated WS Average Typing Score
Z	-1.287[b]
Asymp. Sig. (2-tailed)	.198

a. Wilcoxon signed ranks test

b. Based on negative ranks

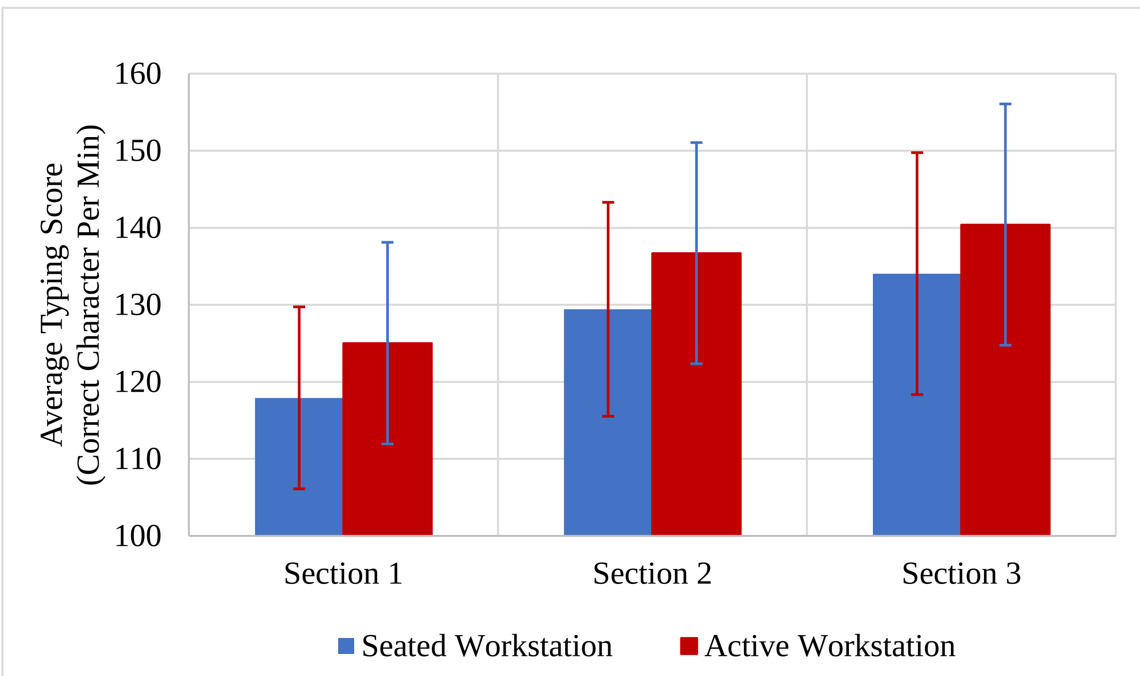

Figure 3. 2 Average Typing Scores by Sections for Each Workstation

The results of the statistical analysis of the average typing scores obtained from the seated and active workstations are presented in Table 3.2. The means of the average typing test scores for the two workstations show that participants were better when at active (μ = 134.05) rather than seated (μ = 127.13) workstation. However, when tested statistically via the Wilcoxon signed rank test, a significant difference could not be found ($p = 0.198$) between the typing scores (see Table 3.2). Since this result only represent the average of the three sections, it was not clear if there was an improvement in typing test performance across sections. Therefore, the sections were assessed individually for the selected workstation in order to illustrate their impact on a participant's typing performance. A plot was generated based on the same data to show this change in average typing score across sections. This section-oriented data for the seated (blue line) and active (red line) workstation can be found in Figure 3.2.

The descriptive statistics for the typing scores per section for the seated and active workstations are presented in Tables 3.3 and 3.4. Depending on the number of repetitive sections, the Friedman tests, a non-parametric repeated-measures ANOVA, was used to determine any significant differences between the sections by condition. The results of this statistical test, including the Chi-square and p-value, are shown in Table 3.5.

Table 3. 3 Descriptive Statistics for Average Typing Scores by Section for the Active Workstation

	N	Mean	Std. Deviation	Min	Max
Seated Workstation Section 1	14	117.9246	45.8631	26.5981	211.9908
Seated Workstation Section 2	14	129.4176	53.9301	21.79626	244.4756
Seated Workstation Section 3	14	134.0499	60.9763	17.8991	271.0600

Table 3. 4 Descriptive Statistics for Average Typing Scores by Section for the Seated Workstation

	N	Mean	Std. Deviation	Min	Max
Active Workstation Section 1	14	125.0279	50.8164	39.4963	259.0419
Active Workstation Section 2	14	136.7026	55.7537	28.4959	282.436
Active Workstation Section 3	14	140.4154	60.8097	22.1991	290.5994

Table 3. 5 Statistical Test Results for Typing Scores (Friedman Test)

Test Statistics[a]	Seated Workstation	Active Workstation
N	14	14
Chi-Square	5.571	13.857
df	2	2
Asymp. Sig.	.062	.001

a. Friedman test

The results of the statistical analysis of the typing scores by section obtained from the seated and active workstations are presented in Table 3.5. The mean typing test scores by section for seated (μ_1 = 117.92, μ_2 = 129.42, μ_3 = 134.05) and active (μ_1= 125.03, μ_2 = 136.70, μ_3 = 140.41) workstation shows that participants` performances improved across sections. For the typing task typing score trials, both conditions improved remarkably over time. After statistical testing via the Friedman repeated-measures test, a significant difference was found for the active workstation ($p = 0.001$) but not for the seated workstation ($p = 0.062$) (see Table 3.5).

3.1.2 The Math Task

For the math task, continuous data were collected in units of completed number of answers per block and number of errors per block for five blocks (combined by algebra), for the three sections and each condition. Individual math task scores were determined by correct answers per minute and calculated by subtracting the total number of errors from the total number of answers, and then dividing that value by the total time per section [(Total Answers – Total Errors) / 8.33 minutes (500 seconds)]. Average math scores per person were calculated by taking the average of the three sections for each condition. These condition-oriented data for the seated (blue block) and active (red block) workstation are given in Figure 3.3.

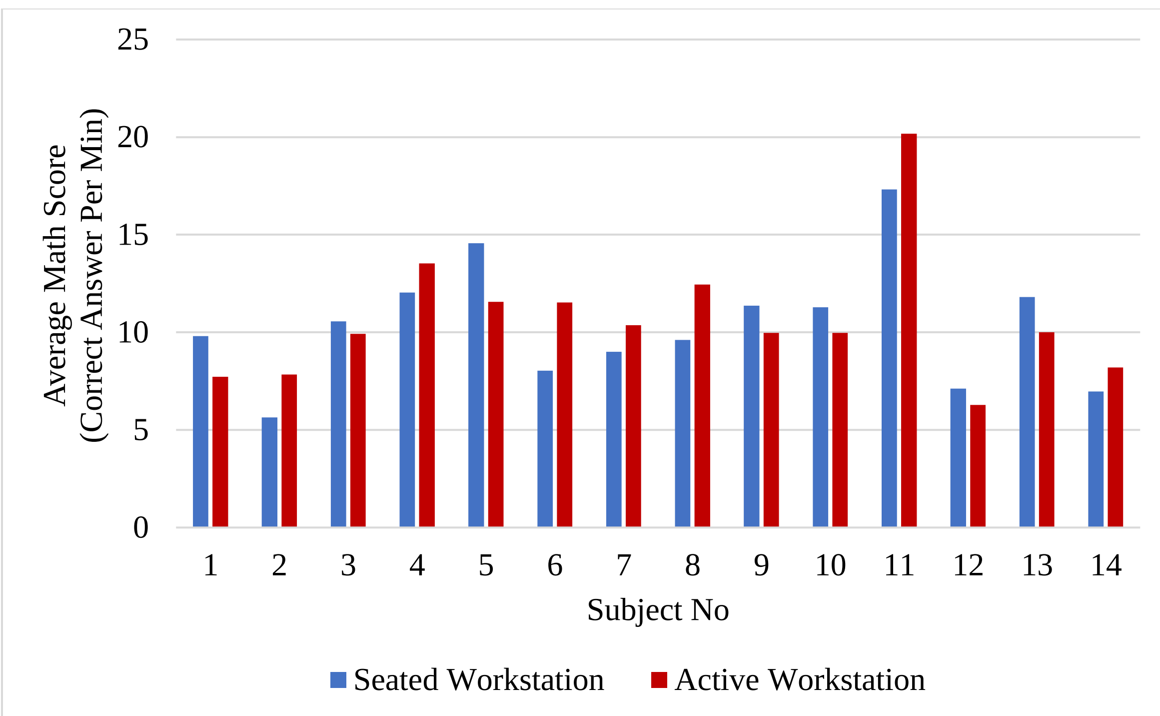

Figure 3. 3 Average Math Scores for Different Workstations

The descriptive statistics for the average math scores for each condition are presented in Table 3.6. These data were tested by a Wilcoxon signed rank test to analyze whether there were significant differences. The results of this statistical test, including Z-score and p-value, are shown in Table 3.7.

Table 3. 6 Descriptive Statistics for Average Math Scores by Condition

	N	Mean	Std. Deviation	Min	Max
Seated Workstation Average Math Score	14	10.367	3.1061	5.6422	17.3269
Active Workstation Average Math Score	14	10.6785	3.3643	6.2825	20.168

Table 3. 7 Statistical Results for Math Scores (Wilcoxon Signed Rank Test)

Test Statistics[a]	Active WS Average Math Score – Seated WS Average Math Score
Z	-.597[b]
Asymp. Sig. (2-tailed)	.551

a. Wilcoxon signed rank test

b. Based on negative ranks

The results of the statistical analysis for the average math scores obtained for the seated and active workstations are presented in Table 3.7. The means of the average math test scores for the two workstations show that participants obtained three more correct answers in their 10 minutes at the active workstation ($\mu = 10.68$) than at the seated workstation ($\mu = 10.37$). However, when this was statistically tested by a Wilcoxon signed rank test, no significant differences were found (p = 0.551) between the math scores (see Table 3.7). Since this result only represents the average of the three sections, it was unclear if there was an increase in math test performance across sections. Therefore, the sections were assessed individually for the selected workstation to determine understand its impact on the participants' math performance. A plot was generated based on these data to show this change in average math scores across sections. These section-oriented data for the seated (blue line) and active (red line) workstations are shown in Figure 3.4.

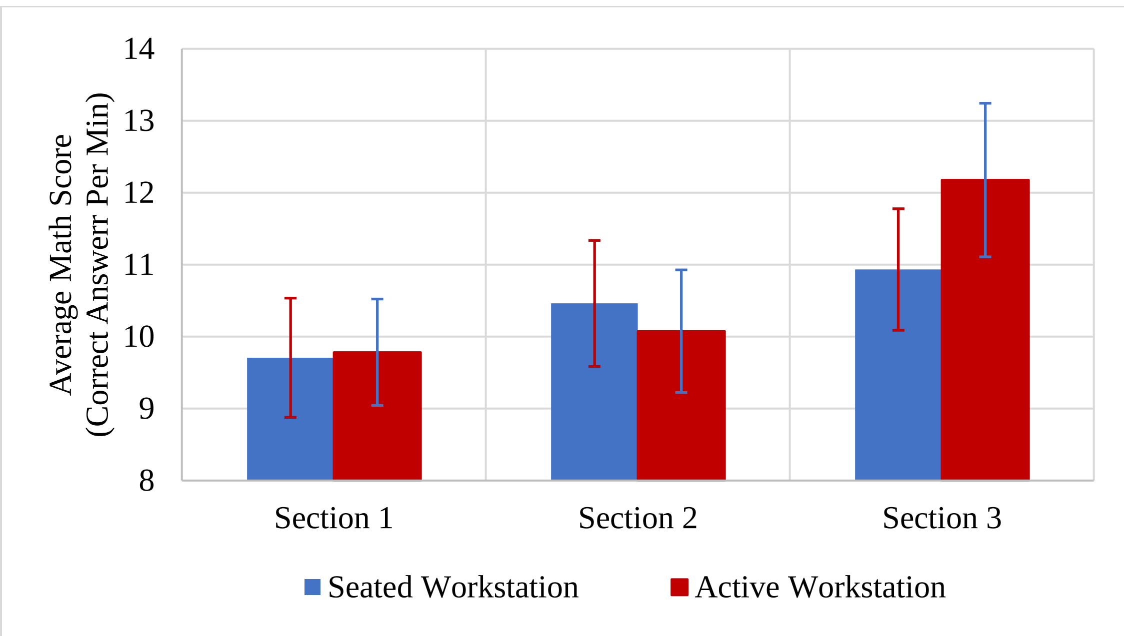

Figure 3. 4 Average Math Scores by Sections for Each Workstation

The descriptive statistics for the math scores by section for the seated and active workstations are presented in Table 3.8 and 3.9. Based on the number of repetitive sections, a Friedman tests and non-parametric repeated-measures ANOVA were used to determine if there were significant differences among the sections by condition. The results of this statistical test, including Chi-square and p-value, are shown in Table 3.10.

Table 3. 8 Descriptive Statistics for Average Math Scores by Section for the Seated Workstation

	N	Mean	Std. Deviation	Min	Max
Seated Workstation Section 1	14	9.7067	3.2180	5.4021	15.006
Seated Workstation Section 2	14	10.4613	3.3986	6.3625	18.8475
Seated Workstation Section 3	14	10.9329	3.2793	5.162	18.1272

Table 3. 9 Descriptive Statistics for Average Math Scores by Section for the Active Workstation

	N	Mean	Std. Deviation	Min	Max
Active Workstation Section 1	14	9.7839	2.8694	6.1224	17.1668
Active Workstation Section 2	14	10.0754	3.3083	6.2424	19.5678
Active Workstation Section 3	14	12.1762	4.1443	6.4825	23.7695

The statistical analysis results for the math scores by section obtained for the seated and active workstations are presented in Table 3.10. The means of the math test scores by sections for the seated (μ_1 = 9.71, μ_2 = 10.46, μ_3 = 10.93) and active (μ_1 = 9.78, μ_2 = 10.07, μ_3 = 12.18) workstations show that participants` performance increased across sections. For the math task math score trials, both conditions improved moderately over time. After statistical testing via the

Friedman repeated-measures test, a significant difference was found for the active workstation (p = 0.000) but not for the seated workstation (p = 0.223) (see Table 3.10).

Table 3. 10 Statistical Test Results for Math Scores (Friedman Test)

Test Statistics[a]	Seated Workstation	Active Workstation
N	14	14
Chi-Square	3.000	19.745
df	2	2
Asymp. Sig.	.223	.000

a. Friedman test

3.1.3 The Word Search Task

For the word search task in the performance test battery, continuous data were collected in units of the number of words per puzzle and numbers of words located according to the three sections for each condition. Individual word search task scores were determined by the number of words found per minute and calculated by dividing the number of words found by the section time (Found Words/ 8 minutes). The average word search scores per person were calculated by taking the average of the three sections for each condition. This condition-oriented data for the seated (blue block) and active (red block) workstations are given in Figure 3.5.

The descriptive statistics for the average word search scores for each condition are presented in Table 3.11. These data were tested by a Wilcoxon signed rank test to analyze whether there were any significant differences. The results of this statistical test, including Z-score and p-value, are shown in Table 3.12.

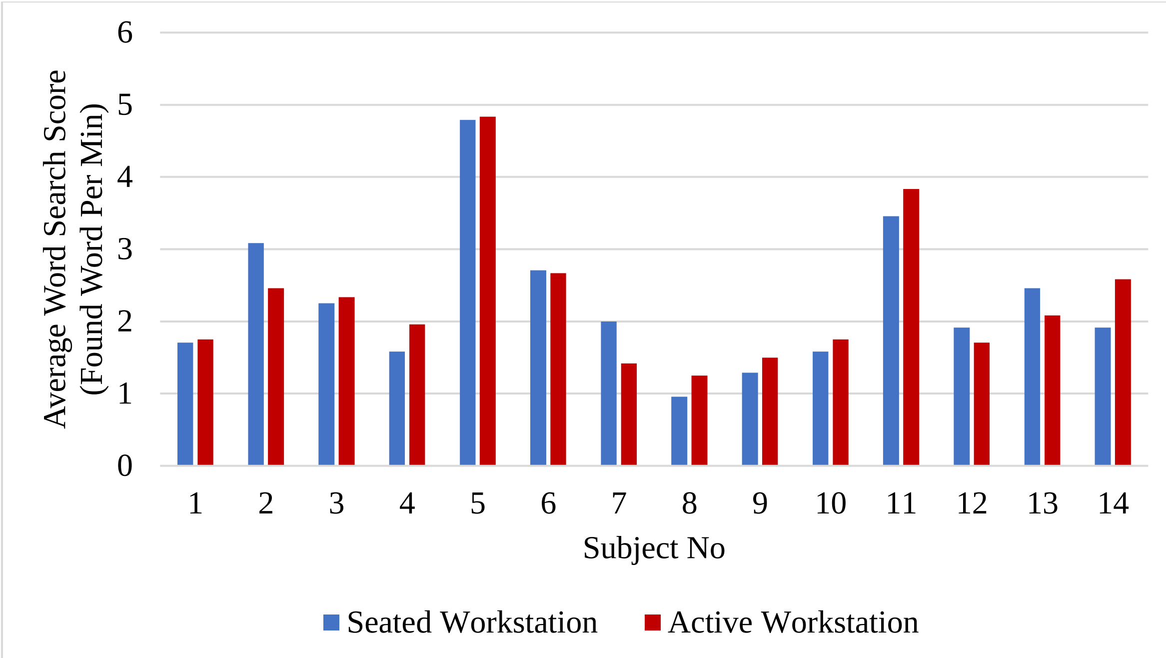

Figure 3. 5 Average Word Search Scores by Different Workstation

Table 3. 11 Descriptive Statistics for the Average Word Search Scores for the Different Workstations

	N	**Mean**	**Std. Deviation**	**Min**	**Max**
Seated Workstation Average Word Search Score	14	2.2648	.9968	.9583	4.7916
Active Workstation Average Word Search Score	14	2.2946	.9864	1.25	4.83

The results of the statistical analysis for the average word search scores obtained for the seated and active workstations are presented in Table 3.12. The mean average word search test scores for the two workstations show that participants obtained similar scores at the active (μ =

2.29) and seated (μ = 2.26) workstations. When statistically tested by a Wilcoxon signed rank test, no significant differences were found ($p = 0.551$) among the word search scores (see Table 3.12).

Table 3. 12 Statistical Test Results for Word Search Scores (Wilcoxon Signed Rank Test)

Test Statistics[a]	Active WS Average Word Search Score – Seated WS Average Word Search Score
Z	-.566[b]
Asymp. Sig. (2-tailed)	.571

a. Wilcoxon signed ranks test

b. Based on negative ranks

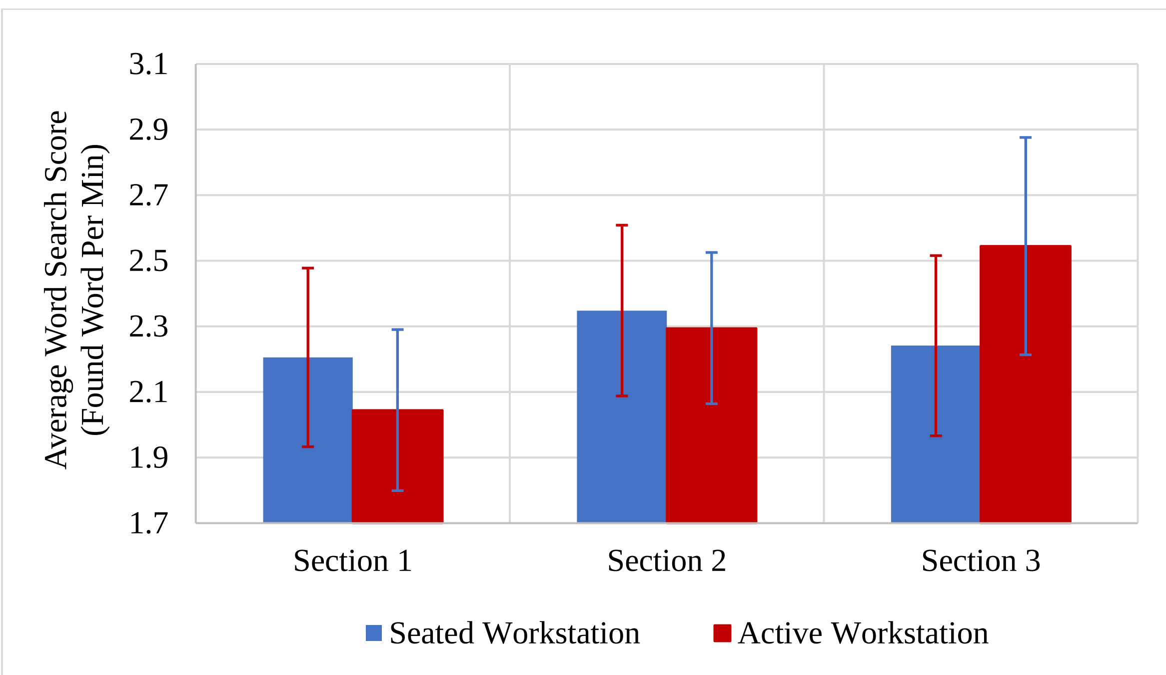

Figure 3. 6 Average Word Search Scores by Section for the Different Workstations

Since this result only represents the average of the three sections, it was difficult to determine if there was an increase in word search test performance across sections. Therefore, the sections were individually assessed for the selected workstation in order to better understand the impact on the participants' word search performance. A plot was generated based on the same data to show this change in average word search score across sections. This section-oriented data for the seated (blue line) and active (red line) workstation are shown in Figure 3.6.

Table 3. 13 Descriptive Statistics for Average Word Search Scores by Section for the Active Workstation

	N	Mean	Std. Deviation	Min	Max
Seated Workstation Section 1	14	2.2053	1.0579	.875	5.250
Seated Workstation Section 2	14	2.3482	1.0109	1.125	4.875
Seated Workstation Section 3	14	2.241	1.0668	.875	4.250

Table 3. 14 Descriptive Statistics for Average Word Search Scores by Section for the Seated Workstation

	N	Mean	Std. Deviation	Min	Max
Active Workstation Section 1	14	2.0446	.9539	1.0	4.625
Active Workstation Section 2	14	2.2946	.8955	1.125	4.250
Active Workstation Section 3	14	2.5446	1.2865	1.375	6.0

The descriptive statistics for the word search scores by section for the seated and active workstations are presented in Tables 3.13 and 3.14. Based on the number of repetitive sections, a Friedman test and non-parametric repeated-measures ANOVA were used to determine if there were significant differences among the sections by condition. The results of the statistical testing, including Chi-square and p-value, are shown in Table 3.15.

Table 3. 15 Statistical Test Results for Word Search Scores (Friedman Test)

Test Statistics[a]	Seated Workstation	Active Workstation
N	14	14
Chi-Square	0.34	7.815
df	2	2
Asymp. Sig.	.844	.020

a. Friedman test

The results of the statistical analysis for the word search scores by section obtained for the seated and active workstations are presented in Table 3.15. The means of the word search test scores by sections for the seated (μ_1 = 2.205, μ_2 = 2.348, μ_3 = 2.241) and active (μ_1 = 2.045, μ_2 = 2.295, μ_3 = 12.18) conditions show that participants` performances improved across sections. The word search task search scores from trials completed at the for active workstation increased linearly over time. After statistical testing by the Friedman repeated-measures test, a significant difference was found for the active workstation (p = 0.020) but not for the seated workstation (p = 0.844) (see Table 3.15).

3.2. Cognitive Test Battery

A cognitive test battery was used to determine if participants' cognitive performances were affected by two different workstations (i.e., seated and active). The battery measured test scores and response times as outcome measures in order to determine the effects of using the different workstations. Five different cognitive tests were performed: the Corsi block, Sternberg memory, the digit span, the Mackworth clock, and the Stroop tests. In order to assess the cognitive test battery, separate scores and time responses were calculated for each cognitive test.

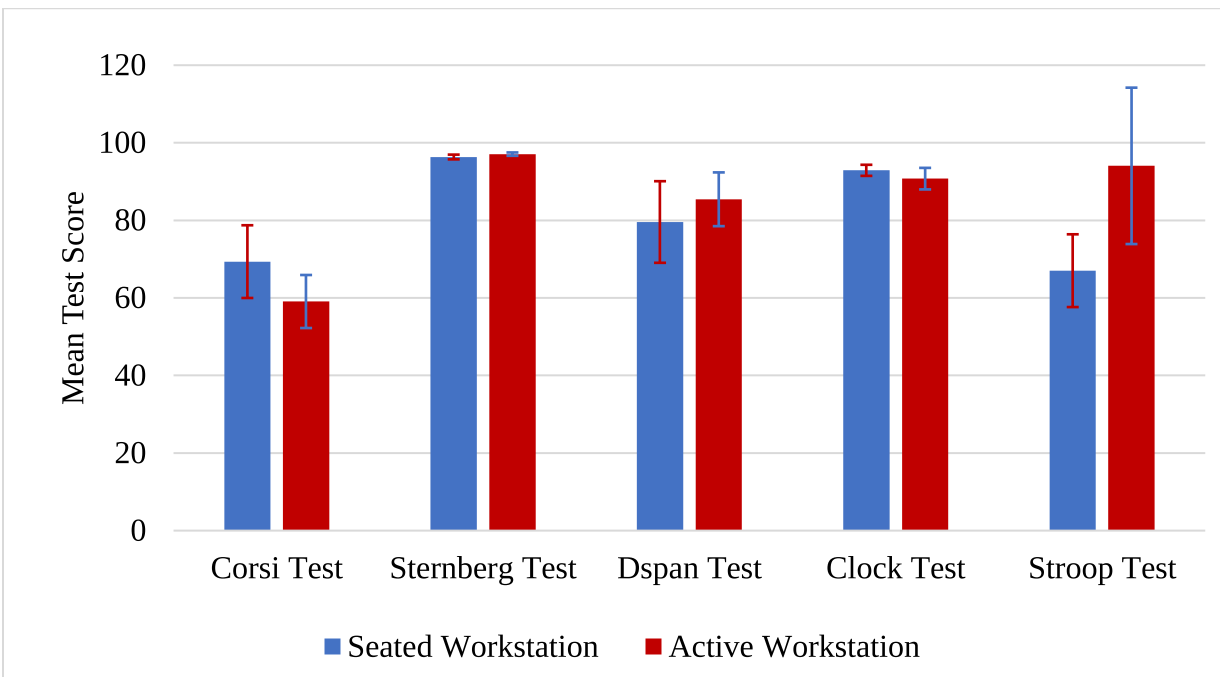

Figure 3. 7 Mean Scores for the Cognitive Test Battery

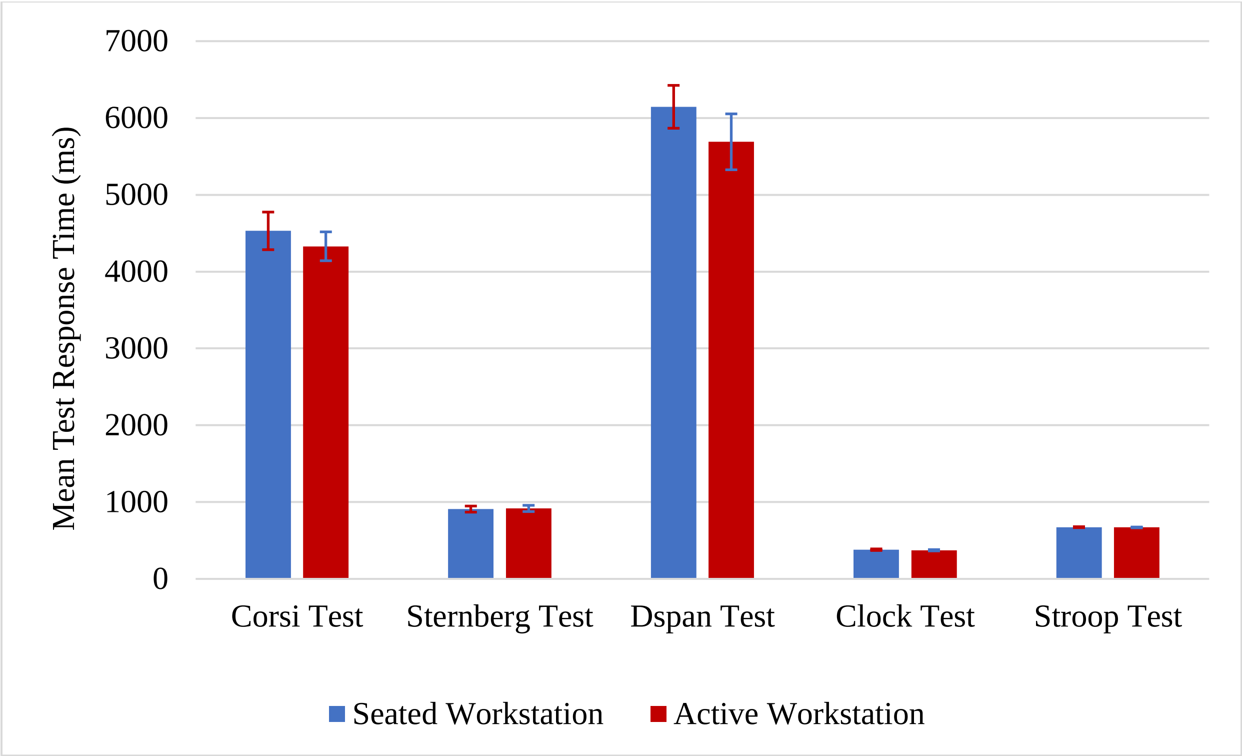

Figure 3. 8 Mean Response Times for the Cognitive Test Battery

The means of the tests scores and test response times for the seated and active workstations are shown in Tables 3.7 and 3.8. To statistically analyze the cognitive test scores and response times, a Wilcoxon signed rank test was used because normality conditions were not satisfied within this group.

3.2.1 The Corsi Block Test

For the Corsi block test in the cognitive test battery, continuous data were collected in units of number of trials, block span, total correct trials, memory span, and response time under each condition.

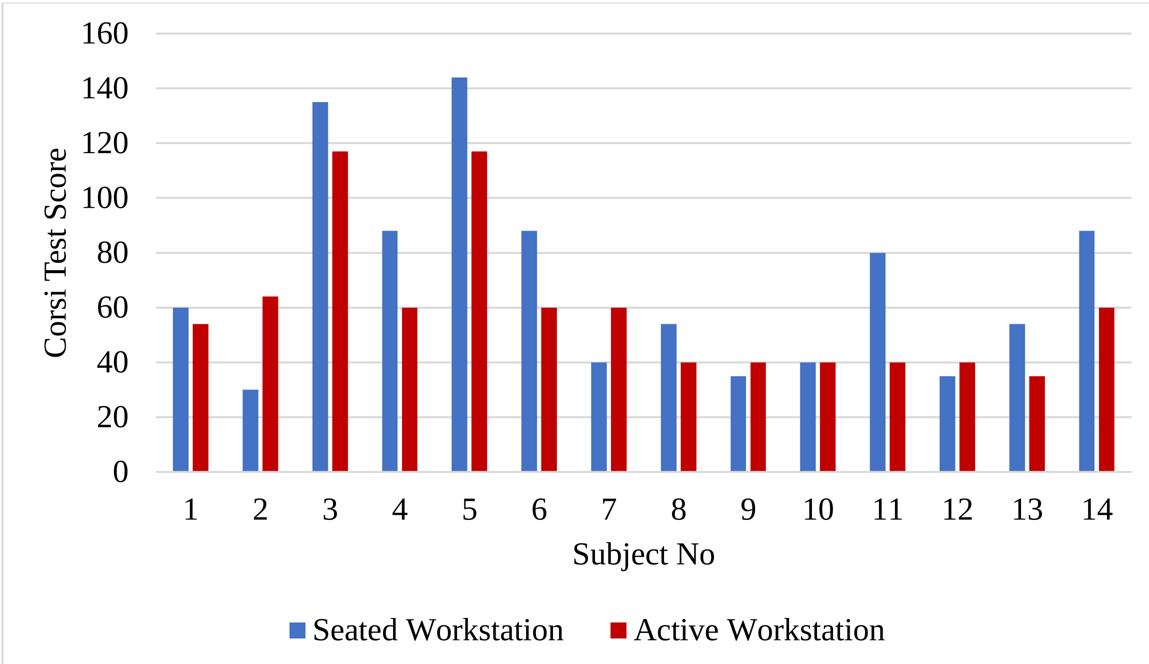

Figure 3. 9 Corsi Test Scores

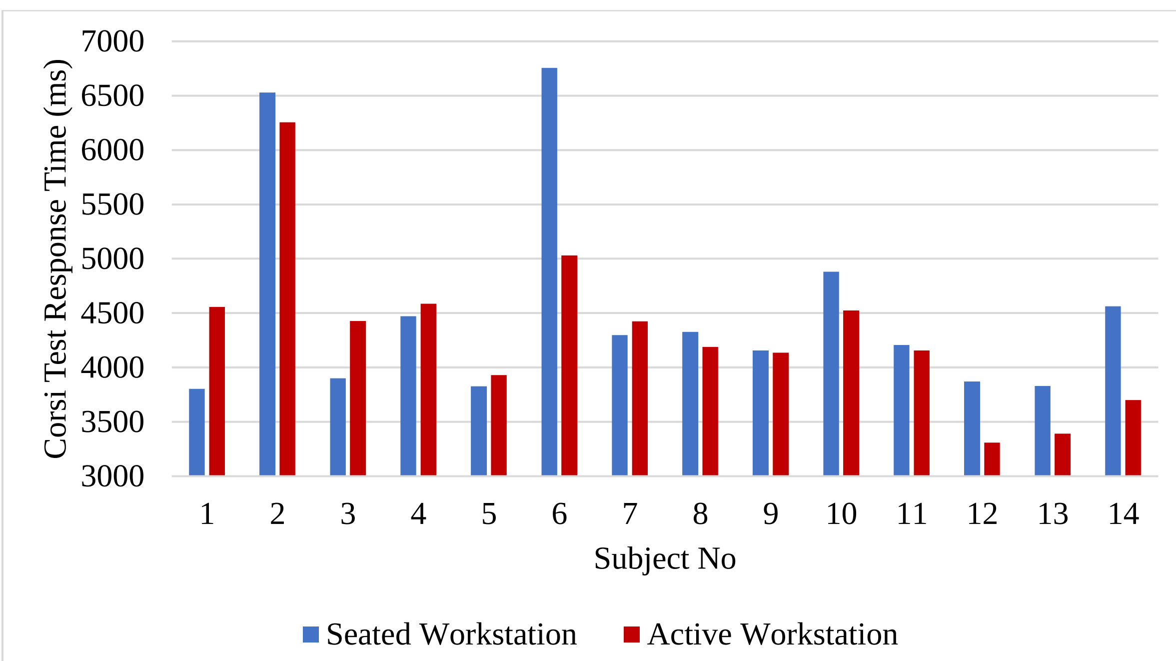

Figure 3. 10 Corsi Test Response Times

Individual Corsi test scores were determined by multiplying the block span and total correct trials (Block Span x Total Correct Trials). The test scores and response times calculated at the seated (blue block) and active (red block) workstations are given in Figures 3.9 and 3.10.

Table 3. 16 Descriptive Statistics for the Corsi Test Scores by Workstations

	N	Mean	Std. Deviation	Min	Max
Seated Workstation Corsi Test Score	14	69.36	36.405	30	144
Active Workstation Corsi Test Score	14	59.07	26.549	35	117

Table 3. 17 Descriptive Statistics for the Corsi Test Response Times for by Workstations

	N	Mean	Std. Deviation	Min	Max
Seated Workstation Corsi Test Response Time	14	4530.4612	951.101	3804.6667	6756.6428
Active Workstation Corsi Test Response Time	14	4329.5999	730.0706	3309.3	6253.85714

The descriptive statistics for the Corsi test scores and response times by condition are presented in Tables 3.16 and 3.17. These data were tested by a Wilcoxon signed rank test in order to analyze whether there were any significantly differences. The results of this statistical test, including Z-score and p-value, are shown in Table 3.18.

Table 3. 18 Statistical Test Results for the Corsi Test Scores and Response Times (Wilcoxon Signed Rank Test)

Test Statistics[a]	Active WS Corsi Test Score – Seated WS Corsi Test Score	Active WS Corsi Test RT – Seated WS Corsi Test RT
Z	-1.645[b]	-1.161[b]
Asymp. Sig. (2-tailed)	.100	.245

a. Wilcoxon signed ranks test

b. Based on negative ranks

The results of the statistical analysis of the Corsi test scores and response times obtained for the seated and active workstations are presented in Table 3.18. The means of the Corsi test scores for the two workstations show that participants obtained higher scores at the seated (μ = 69.36) rather than active (μ=59.07) workstation. However, the means of the participants` response times for the two workstations show that participants were faster at the active (μ = 4329.6) rather than seated (μ = 4530.5) workstation. When statistically tested by the Wilcoxon signed rank test, no significant differences could be found for either the Corsi test scores ($p = 0.1$) and response times ($p = 0.245$) (see Table 3.18).

3.2.2 The Sternberg Memory Test

For the Sternberg memory test in the cognitive test battery, continuous data were collected in units of accuracy and response times for the “present” and “absent” trials (2, 4, and 6 letters) in each condition. Individual Sternberg test scores were determined by calculating the average scores for the 2, 4, and 6-letter trials [e.g., Score of 2 = 50 x Accuracy (2 Present + 2 Absent)].

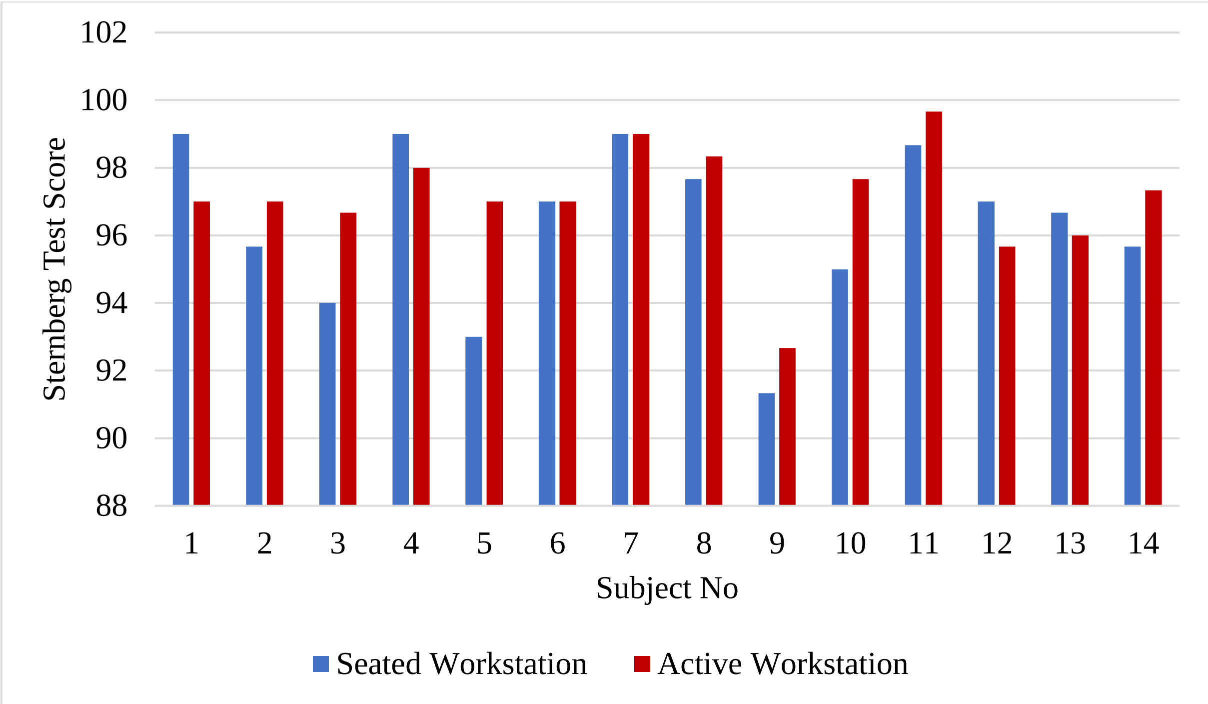

Figure 3. 11 Sternberg Memory Test Scores

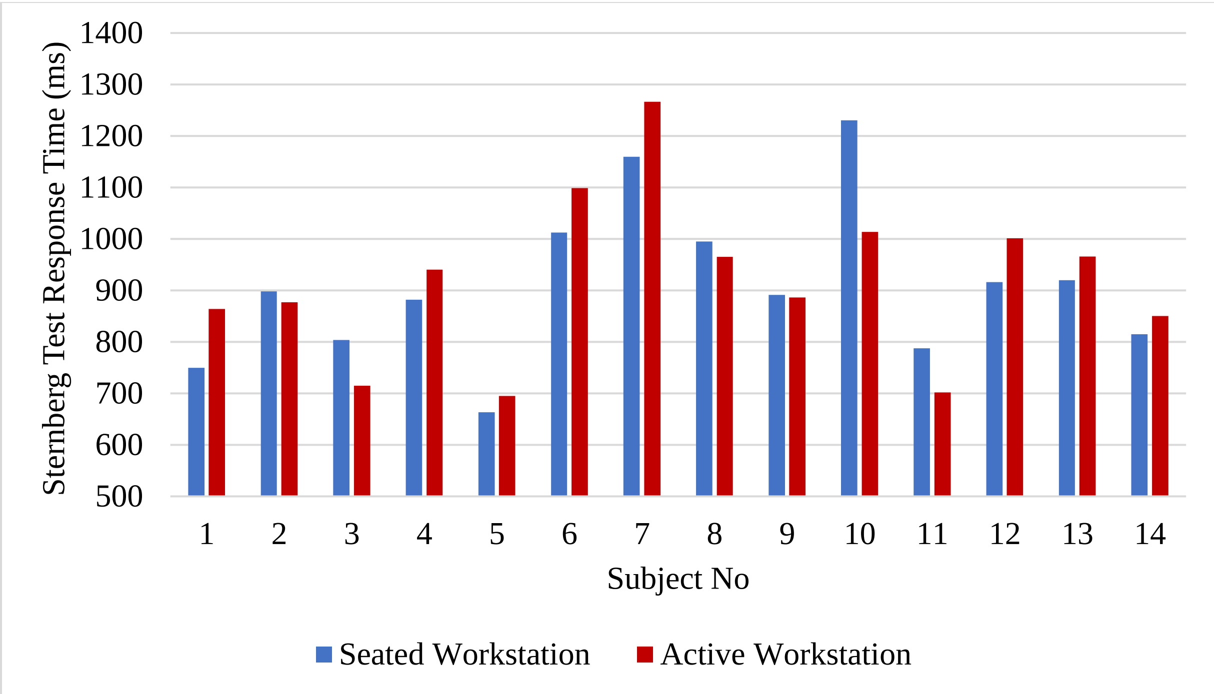

Figure 3. 12 Sternberg Memory Test Response Times

The calculated test scores and response times for the Sternberg test for the seated (blue block) and active (red block) workstations are given in Figures 3.11 and 3.12.

Table 3. 19 Descriptive Statistics of the Sternberg Memory Test Scores by Workstations

	N	Mean	Std. Deviation	Min	Max
Seated Workstation Sternberg Test Score	14	96.3334	2.3822	91.3334	99.0
Active Workstation Sternberg Test Score	14	97.0714	1.665	92.6667	99.6667

Table 3. 20 Descriptive Statistics for the Sternberg Memory Test Response Times by Workstations

	N	Mean	Std. Deviation	Min	Max
Seated Workstation Sternberg Test Response Time	14	908.7738	153.4037	663.3334	1230.3334
Active Workstation Sternberg Test Response Time	14	917.119	157.6713	694.8334	1266.1667

The descriptive statistics for Sternberg test scores and response times for each condition are presented in Tables 3.19 and 3.20. These data were tested by the Wilcoxon signed rank test in order to analyze whether there were any significant differences. The results of this statistical test, including Z-score and p-value, are shown in Table 3.21.

Table 3. 21 Statistical Test Results for the Stenberg Memory Test Scores and Response Times (Wilcoxon Signed Rank Test)

Test Statistics[a]	Active WS Sternberg Test Score – Seated WS Sternberg Test Score	Active WS Sternberg Test RT – Seated WS Sternberg Test RT
Z	-1.495[b]	-.785[b]
Asymp. Sig. (2-tailed)	.135	.433

a. Wilcoxon signed ranks test

b. Based on negative ranks

The results of the statistical analysis of the Sternberg test scores and response times obtained for the seated and active workstations are presented in Table 3.21. While the means of the Sternberg test scores for the two workstations show that participants obtained similar scores for both the active (μ = 97.07) and seated (μ=96.34) workstation, the means of the participants` response times for the two workstations show that participants were faster at the seated (μ = 908.77) rather than active (μ = 917.12) workstations. When statistically tested by the Wilcoxon signed rank test, no significant difference could be found for the Sternberg test scores ($p = 0.135$) or response times ($p = 0.433$) (see Table 3.21).

3.2.3 The Digit Span Test

For the digit span test in the cognitive test battery, continuous data were collected in units of total number correct and memory span and response times for each condition. Individual digit span test scores were determined by multiplying the memory span time by the total number correct (Memory Span x Total Correct).

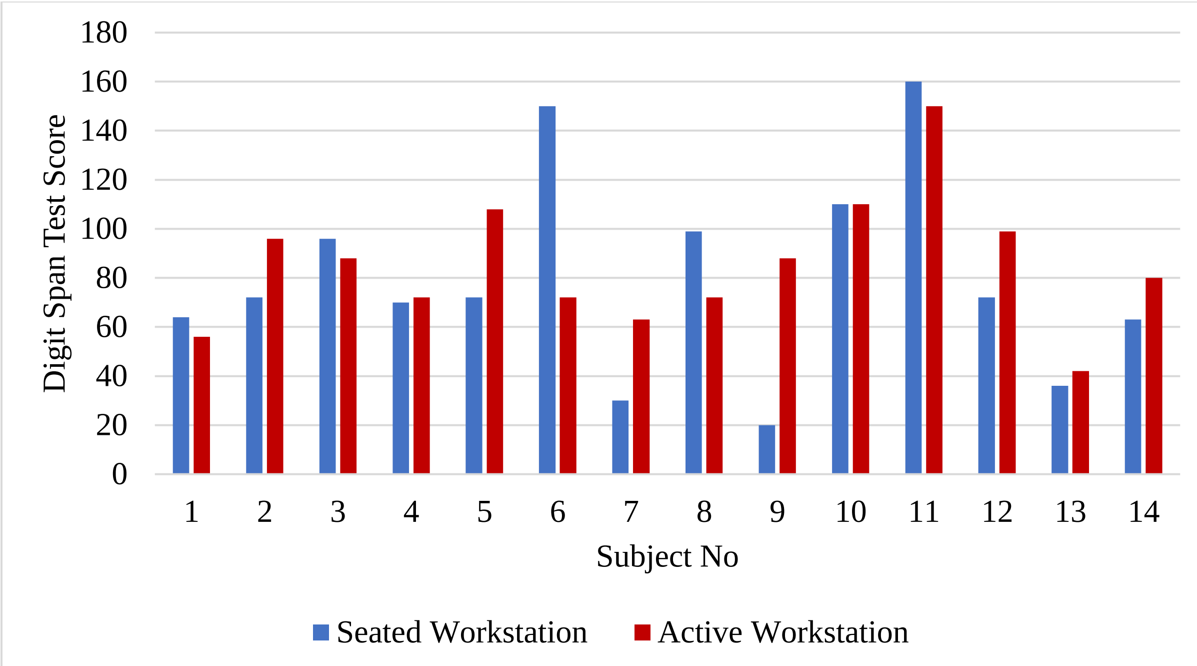

Figure 3. 13 Digit Span Test Scores

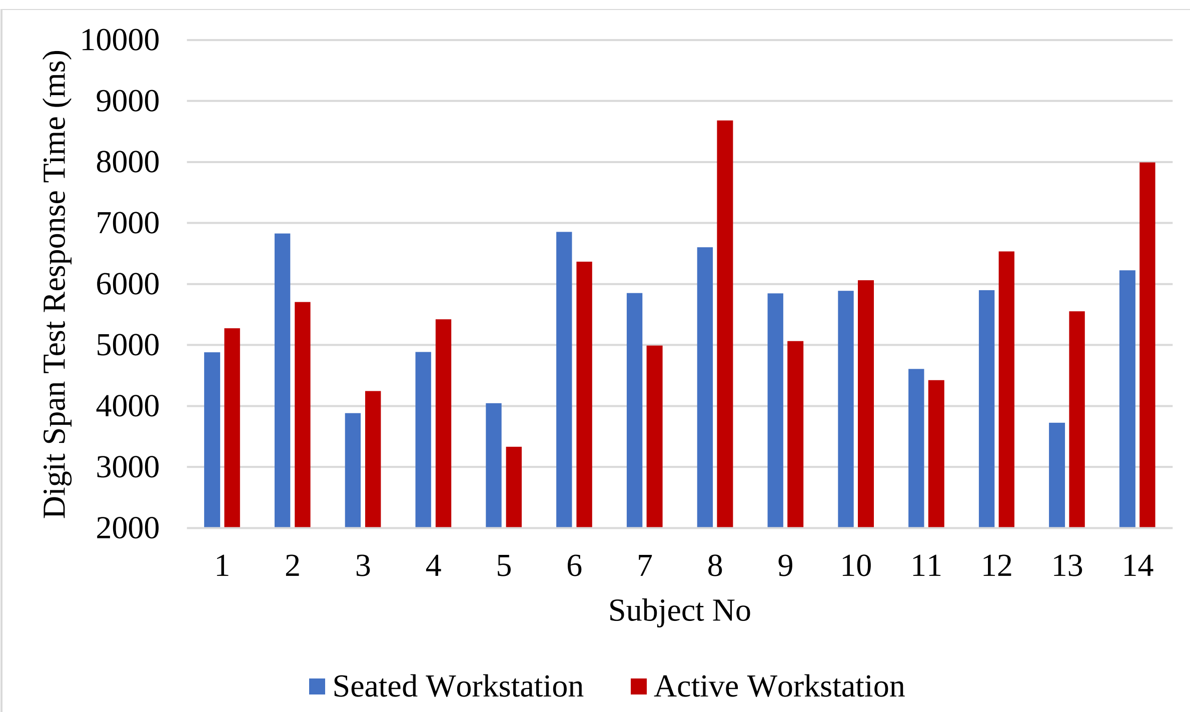

Figure 3. 14 Digit Span Test Response Times

The test scores and response times calculated for the digit span test for the seated (blue block) and active (red block) workstations are given in Figures 3.13 and 3.14.

Table 3. 22 Descriptive Statistics for the Digit Span Test Scores by Workstations

	N	Mean	Std. Deviation	Min	Max
Seated Workstation Digit Span Test Score	14	79.57	40.844	20	160
Active Workstation Digit Span Test Score	14	85.43	26.915	42	150

Table 3. 23 Descriptive Statistics of the Digit Span Test Response Times by Workstations

	N	Mean	Std. Deviation	Min	Max
Seated Workstation Digit Span Test Response Time	14	5431.0974	1083.4965	3727.1	6857
Active Workstation Digit Span Test Response Time	14	5689.667	1412.5701	3333.1875	8680.6428

The descriptive statistics for the digit span test scores and response times for each condition are presented in Tables 3.22 and 3.23. These data were tested by the Wilcoxon signed rank test to analyze whether there were significant differences. The results of this statistical test, including Z-score and p-value, are shown in Table 3.24.

Table 3. 24 Statistical Test Results for the Digit Span Test Scores and Response Times (Wilcoxon Signed Ranks Test)

Test Statistics[a]	Active WS Digit Span Test Score – Seated WS Digit Span Test Score	Active WS Digit Span Test RT – Seated WS Digit Span Test RT
Z	-.839[b]	-.471[b]
Asymp. Sig. (2-tailed)	.401	.638

a. Wilcoxon signed ranks test

b. Based on negative ranks

The results of the statistical analysis of digit span test scores and response times obtained for the seated and active workstations are presented in Table 3.24. While the means of the digit span test scores for the two workstations show that participants received higher scores at the active (μ = 85.43) rather than seated (μ = 79.57) workstation, the means of the participants` response times for the two workstations show that participants were faster at the seated (μ = 5431.1) rather than active (μ = 5689.7) workstation. When this was tested statistically by the Wilcoxon signed rank test, no significant difference could be found for either digit span test scores ($p = 0.401$) or response times ($p = 0.638$) (see Table 3.24).

3.2.4 The Mackworth Clock Test

For the Mackworth clock test in the cognitive test battery, continuous data were collected in units of number of targets (or skips), correct responses, correct targets, false alarms and mean response times for each condition. Individual Mackworth clock test scores were determined by dividing the of number correct targets by the number of total target (100 x Correct Targets / Total Targets).

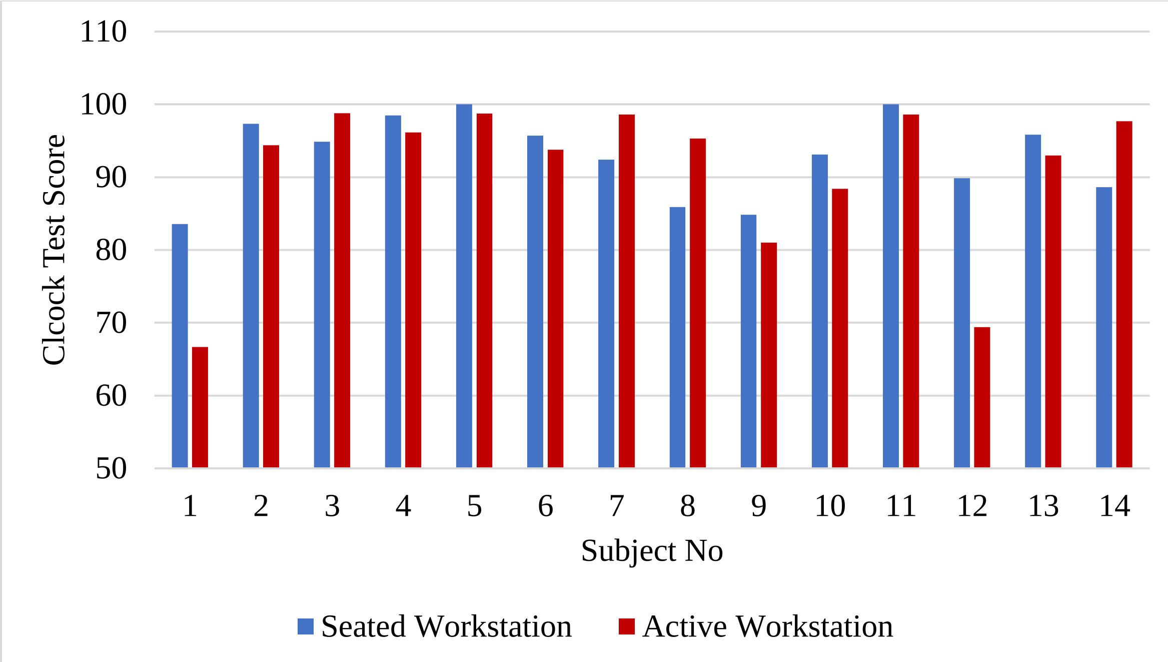

Figure 3. 15 Mackworth Clock Test Scores

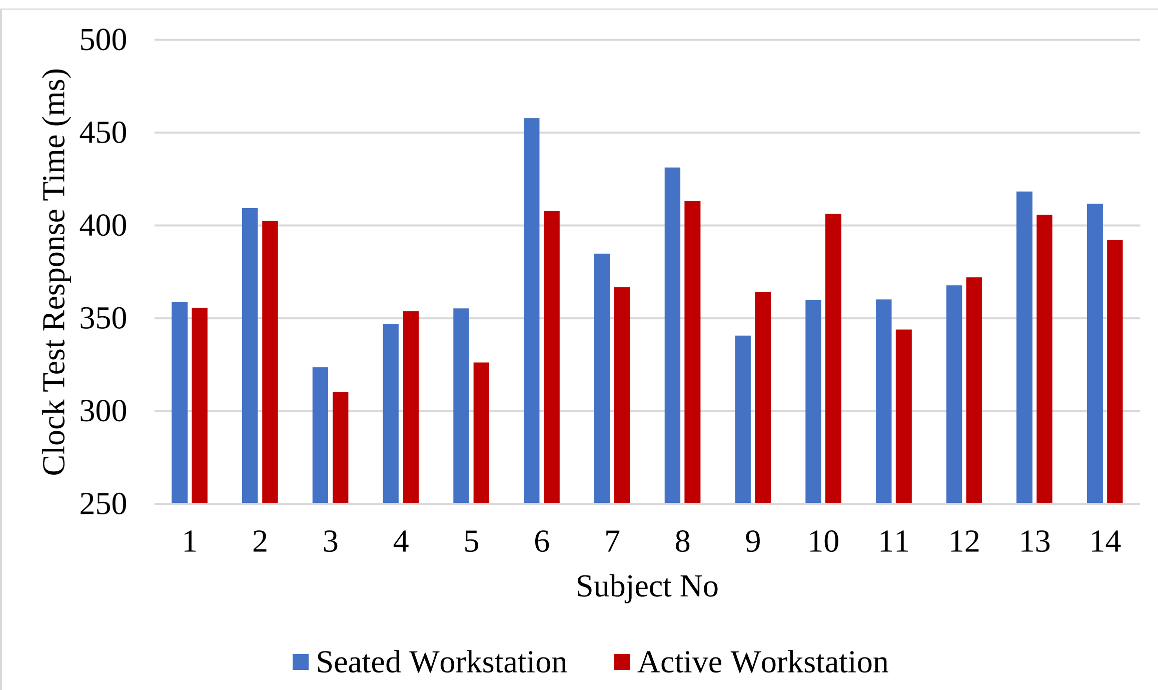

Figure 3. 16 Mackworth Clock Test Response Times

The test scores and response times for the Mackworth clock test for the seated (blue block) and active (red block) workstations are given in Figures 3.15 and 3.16.

Table 3. 25 Descriptive Statistics for the Mackworth Clock Test Scores by Workstations

	N	Mean	Std. Deviation	Min	Max
Seated Workstation Clock Test Score	14	92.8937	5.5527	83.5443	100
Active Workstation Clock Test Score	14	90.7463	10.7864	66.6667	98.7804

Table 3. 26 Descriptive Statistics for the Mackworth Clock Test Response Times by Workstations

	N	Mean	Std. Deviation	Min	Max
Seated Workstation Clock Test Response Time	14	380.4568	39.0791	323.622	457.791
Active Workstation Clock Test Response Time	14	372.882	39.0791	310.358	413.111

The descriptive statistics for the Mackworth clock test scores and response times for each condition are presented in Tables 3.25 and 3.26. These data were tested by the Wilcoxon signed rank test to analyze whether there were any significant differences. The results of this statistical test, including Z-score and p-value, are shown in Table 3.27.

Table 3. 27 Statistical Test Results for the Mackworth Clock Test Scores and Response Times (Wilcoxon Signed Ranks Test)

Test Statistics[a]	Active WS Clock Test Score – Seated WS Clock Test Score	Active WS Clock Test RT – Seated WS Clock Test RT
Z	-1.645[b]	-1.475[b]
Asymp. Sig. (2-tailed)	.100	.140

a. Wilcoxon signed ranks test

b. Based on negative ranks

The results of the statistical analysis of the Mackworth clock test scores and response times obtained for the seated and active workstations are presented in Table 3.27. While the means of the Mackworth clock test scores for the two workstations show that participants received higher scores at the seated (μ = 92.89) rather than active (μ = 90.75) workstation, the means of participants` response times for the two workstations show that participants were faster at active (μ = 372.8) rather than seated (μ = 380.4) workstation. When this was tested statistically by the Wilcoxon signed rank test, no significant differences were found for either the Mackworth clock test scores ($p = 0.1$) or response times ($p = 0.14$) (see Table 3.27).

3.2.5 The Stroop Test

For the Stroop test in the cognitive test battery, continuous data were collected in units of number of errors, cost of the Stroop effect and response time for each condition. Individual Stroop test scores were determined by the percentage of total correct responses. The test scores and response times calculated for the Stroop test for the seated (blue block) and active (red block) workstation are given in Figures 3.17 and 3.18.

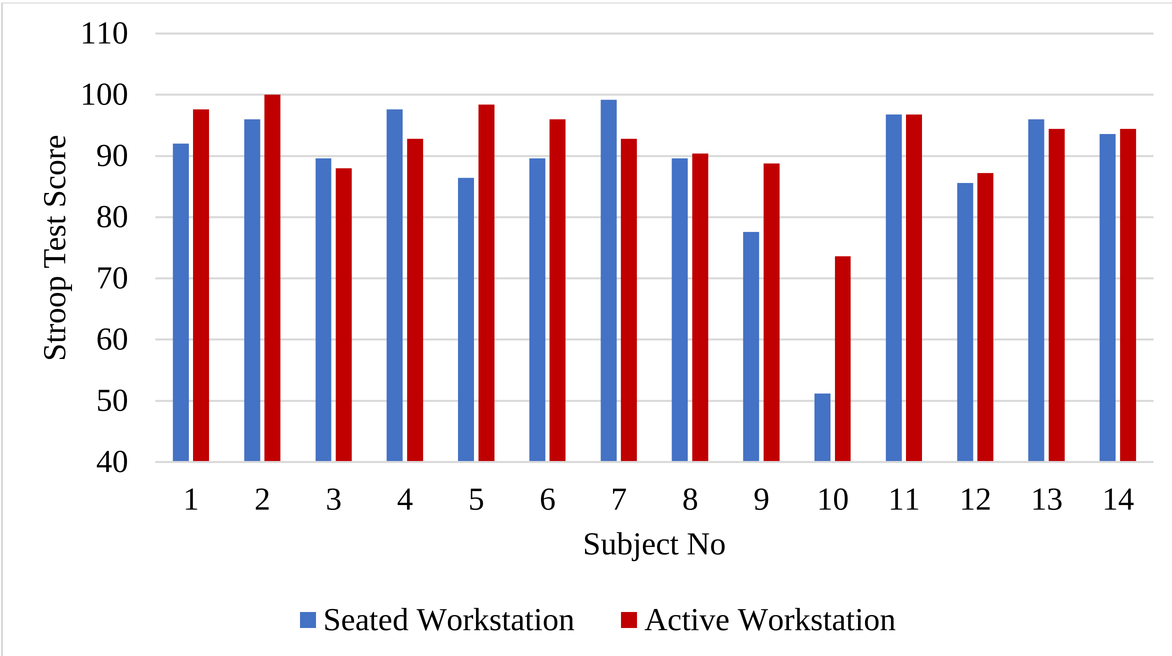

Figure 3. 17 Stroop Test Scores

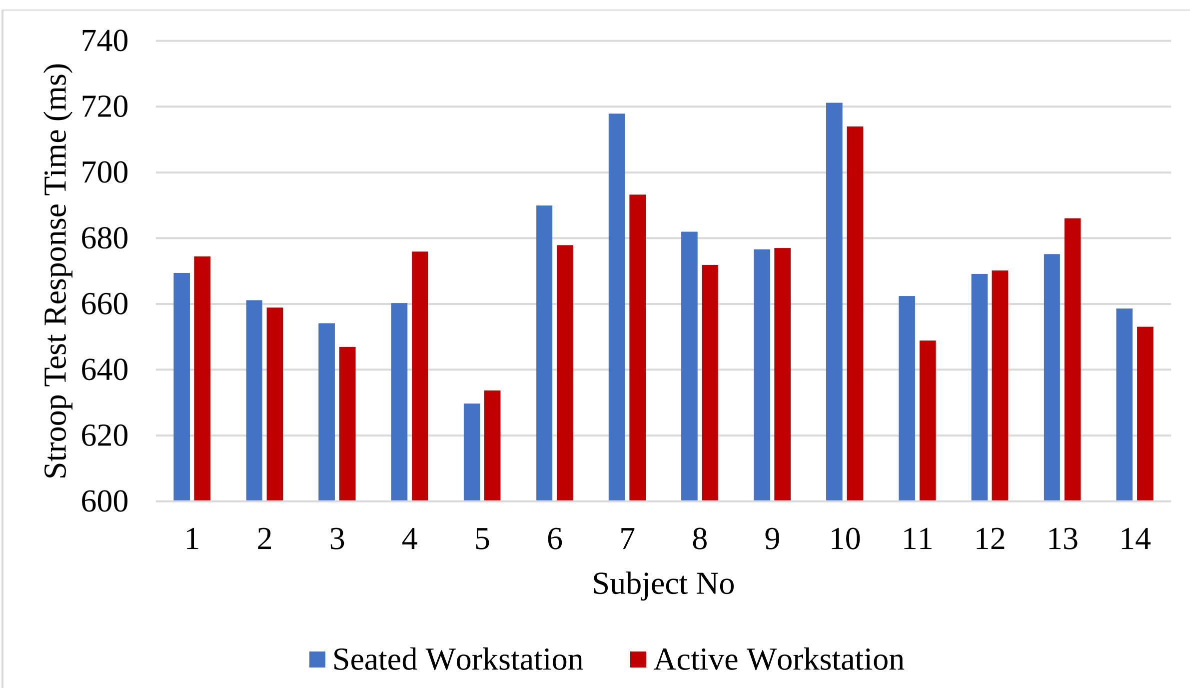

Figure 3. 18 Stroop Test Response Times

Table 3. 28 Descriptive Statistics for the Stroop Test Scores by Workstations

	N	Mean	Std. Deviation	Min	Max
Seated Workstation Stroop Test Score	14	88.6286	12.2262	51.2	99.2
Active Workstation Stroop Test Score	14	92.2286	6.67	73.6	100

Table 3. 29 Descriptive Statistics for the Stroop Test Response Times by Workstations

	N	Mean	Std. Deviation	Min	Max
Seated Workstation Stroop Test Response Time	14	673.3901	24.1834	629.7583	721.1867
Active Workstation Stroop Test Response Time	14	670.1296	20.7727	633.665	713.99

Table 3. 30 Statistical Test Results for the Stroop Test Scores and Response Times (Wilcoxon Signed Rank Test)

Test Statistics[a]	Active WS Stroop Test Score – Seated WS Stroop Test Score	Active WS Stroop Test RT – Seated WS Stroop Test RT
Z	-1.470[b]	-1.099[b]
Asymp. Sig. (2-tailed)	.141	.272

a. Wilcoxon signed ranks test

b. Based on negative ranks

The descriptive statistics for Stroop test scores and response times for each condition are presented in Tables 3.28 and 3.29. These data were tested by the Wilcoxon signed rank test to analyze whether there were any significant differences. The results of this statistical test, including Z-score and p-value, are shown in Table 3.30.

The results of the statistical analysis of the Stroop test scores and response times obtained for the seated and active workstations are presented in Table 3.30. The means of the Stroop test scores for the two workstations show that the participants obtained higher scores at the active ($\mu = 92.29$) rather than seated ($\mu = 88.6$) workstation, and the means of the participants` response times for the two workstations show that the participants were faster at the active (μ=670.13) rather than seated (μ=673.39) workstation. When this was tested statistically by the Wilcoxon signed rank test, no significant difference could be found for either the Stroop test scores ($p = 0.141$) or response times ($p = 0.272$) (see Table 3.30).

3.3 Energy Expenditure

The data taken from the SenseWear Software were recorded during the experiment sessions and calibrated according to each participant's age, height, weight, dominant hand, and smoking habits. In the analysis of these results, the output of total energy expenditure was used to determine how many calories participants expended while using the seated and active workstations. The software generated plot of the total energy expenditures of selected participants for both workstations, as are shown in Figures 3.19 and 3.20.

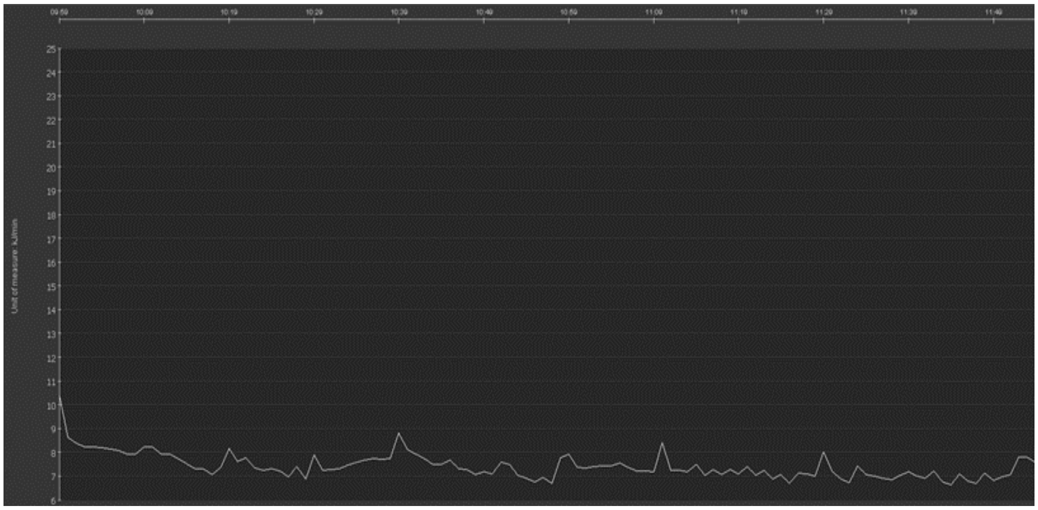

Figure 3. 19 Energy Expenditure of a Selected Participant for the Seated Workstation [32]

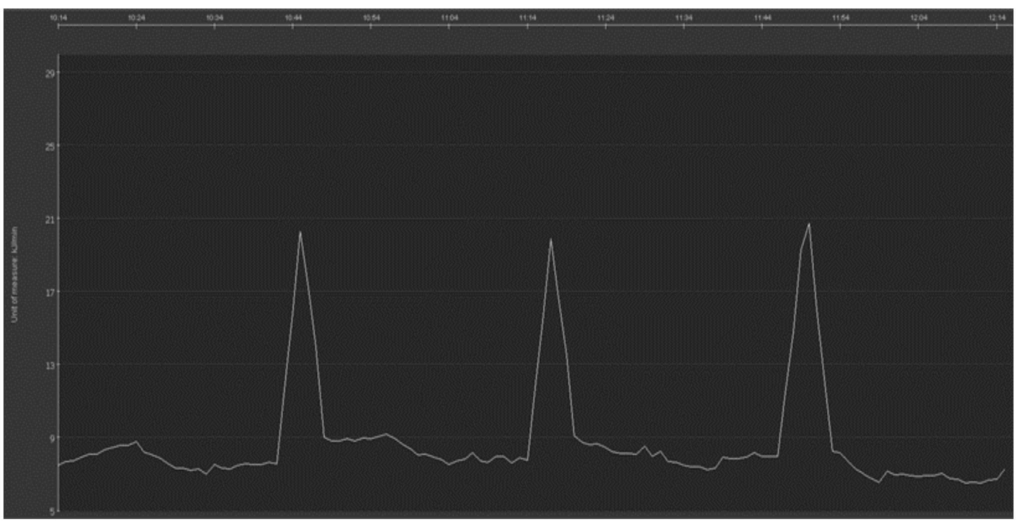

Figure 3. 20 Energy Expenditure of a Selected Participant for the Active Workstation [32]

3.3.1 Total Energy Expenditure

In order to accurately asses the participants' total energy expenditure for each condition, individual energy expenditure datapoints were converted into kilocalories per hour for each workstation. These condition-oriented data for the seated (blue block) and active (red block) workstations are given in Figure 3.21.

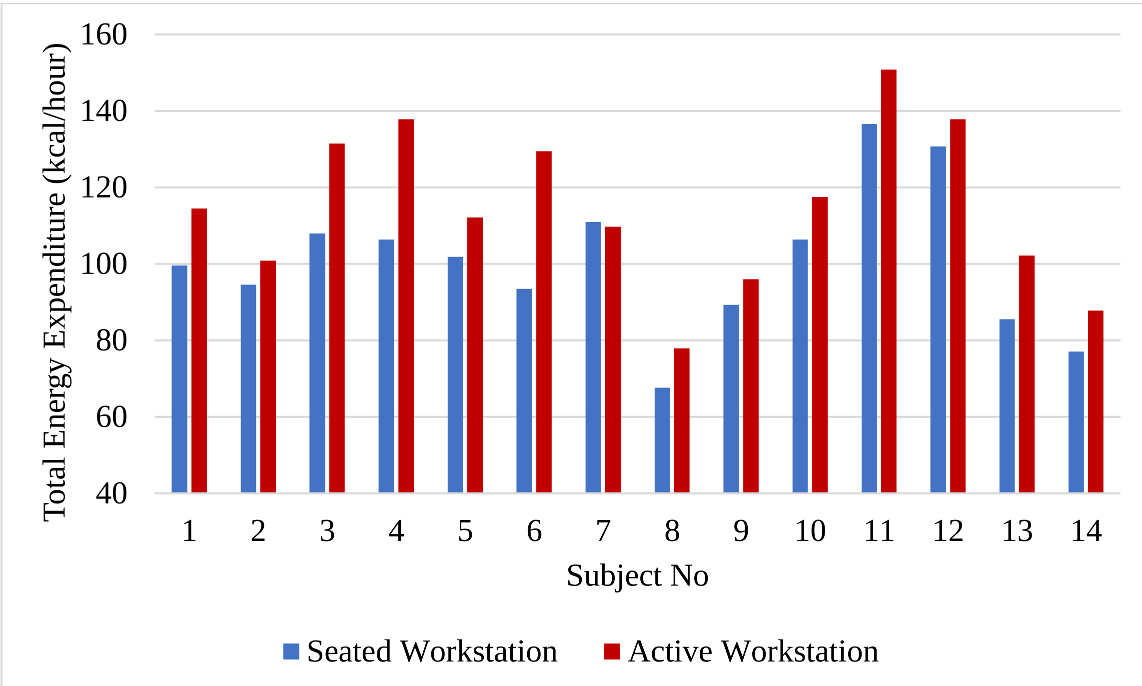

Figure 3. 21 Total Energy Expenditures of Participants by Workstation

In addition, to understand the amount of total energy expenditure, basal metabolic rate was calculated that represents an estimate of calories burned while resting - also know as resting metabolic rate. Basal Metabolic Rate (BMR) was calculated for each participant using the standard formula (i.e., [Women BMR = 655.0955 + 9.5634 x weight (kg) + 1.8496 x height (cm) – 4.6756 x age (years); Men BMR = 66.4730 + 13.7516 x weight (kg) + 5.0033 x height (cm) – 6.7550 x age (years)]) are given in Figure 3.22.

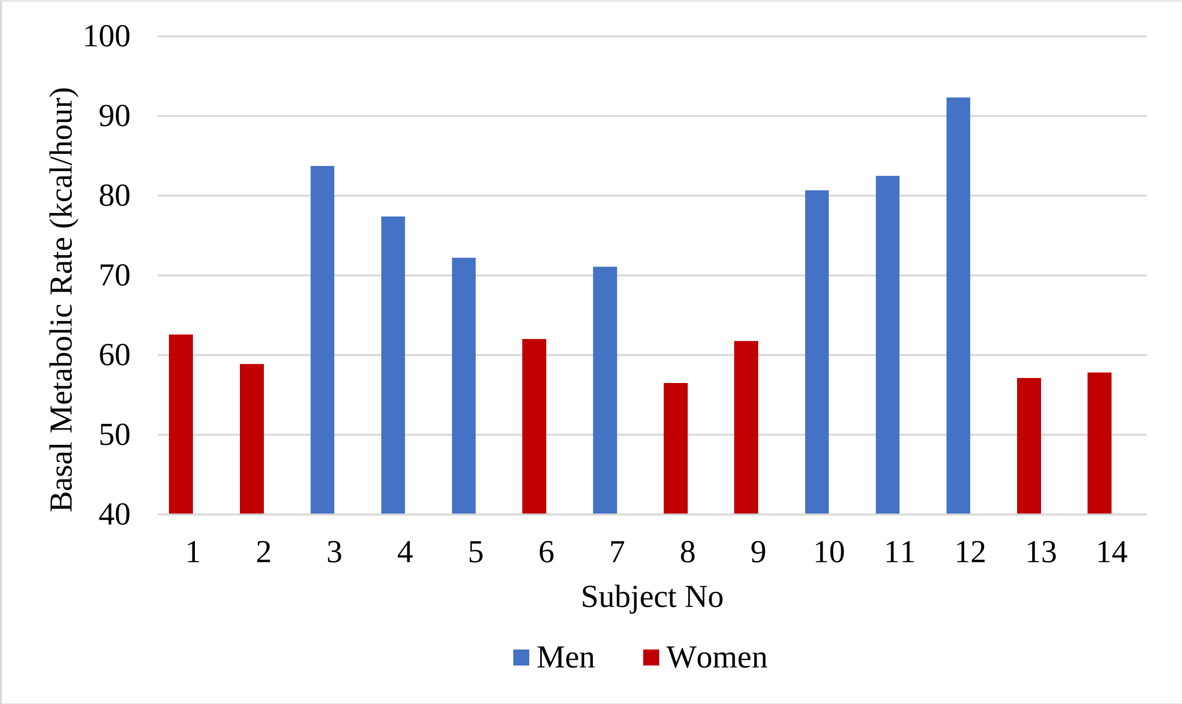

Figure 3. 22 Basal Metabolic Rates of Participant

The descriptive statistics for the participants' total energy expenditures for each condition are presented in Table 3.31. These data were tested by the Wilcoxon signed rank test to analyze whether there were any significant differences. The results of this statistical test, including Z-score and p-value, are shown in Table 3.32.

Table 3. 31 Descriptive Statistics for Total Energy Expenditure by Workstations

	N	Mean (kcal/hr)	Std. Deviation (kcal/hr)	Min (kcal/hr)	Max (kcal/hr)
Seated Workstation Total Energy Expenditure	14	100.5536	18.6394	67.585	136.6073
Active Workstation Total Energy Expenditure	14	114.7029	20.9103	77.9296	150.8172

Table 3. 32 Statistical Test Results for Total Energy Expenditure (Wilcoxon Signed Rank Test)

Test Statistics[a]	Active WS Energy Expenditure – Seated WS Energy Expenditure
Z	-3.233[b]
Asymp. Sig. (2-tailed)	.001

a. Wilcoxon signed ranks test

b. Based on negative ranks

The results of the statistical analysis of the total energy expenditure values obtained for the seated and active workstations are presented in Table 3.32. The means of the average total energy expenditures for the two workstations show that participants used an average of 14 kcal per hour more at the active (μ=114.7) rather than seated (μ=100.5) workstations. When this was analyzed statistically by the Wilcoxon signed rank test, a significant difference was found ($p = 0.01$) between the total energy expenditures for seated and active workstations (see Table 3.32).

3.3.2 Energy Expenditure by Section

The results of the total energy expenditure represented only the average energy expenditures of the three performance sections and one cognitive section. Therefore, they did not demonstrate whether there was any change in energy expenditure across sections. Therefore, the performance and cognitive sections need to assessed by themselves for each selected workstation, in order to understand the impact of using different workstations on participants' energy expenditure. To understand this impact, a plot was generated based on the same data, showing changes in average energy expenditure across sections. These section-oriented data for the seated (blue line) and active (red line) workstations are shown in Figure 3.23.

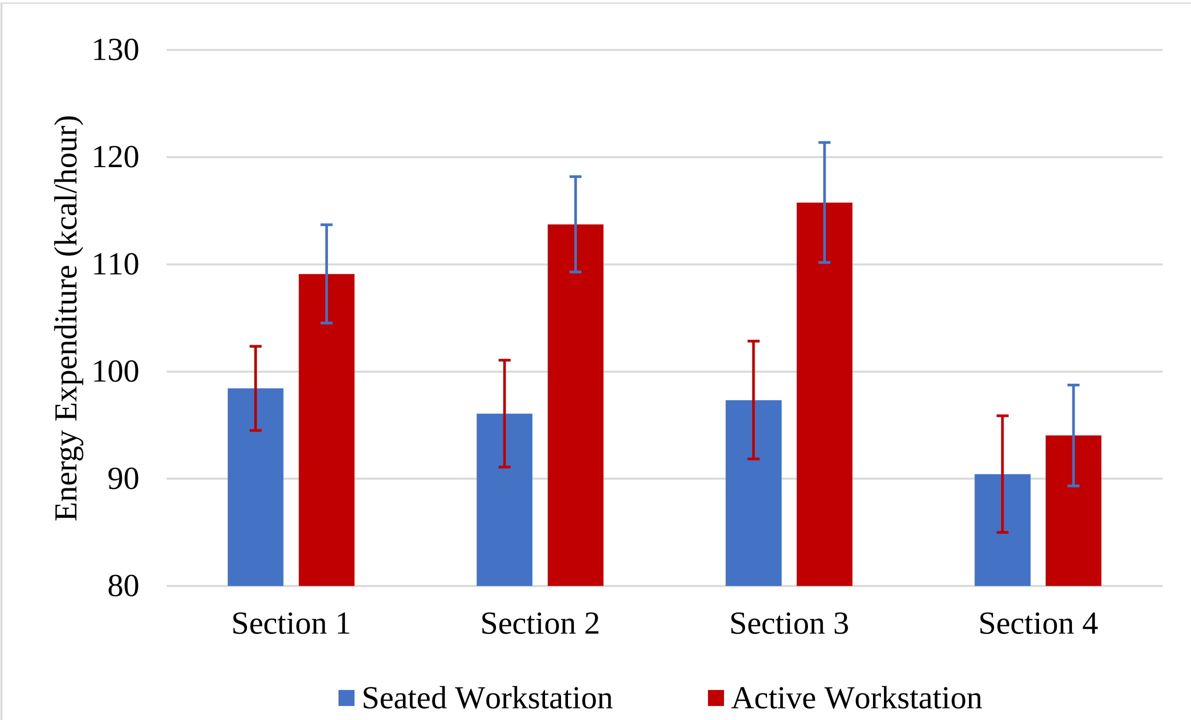

Figure 3. 23 Total Energy Expenditures for Sections by Workstation

The descriptive statistics for the energy expenditures in the performance sections for the seated and active workstations are presented in Tables 3.33 and 3.34. Depending on the number of repetitive sections, the Friedman non-parametric repeated-measures ANOVA test was used to determine if there were significant differences between the sections by condition. The results of this statistical testing, including Chi-square and p-value, are shown in Table 3.35.

Table 3. 33 Descriptive Statistics for the Total Energy Expenditure by Performance Sections for the Seated Workstation

	N	Mean (kcal/hr)	Std. Deviation (kcal/hr)	Min (kcal/hr)	Max (kcal/hr)
Seated Workstation Section 1	14	98.4313	15.235	71.7	125.1041
Seated Workstation Section 2	14	96.0763	17.8033	67.5367	124.1151
Seated Workstation Section 3	14	97.3429	19.3519	63.7882	130.016

Table 3. 34 Descriptive Statistics for the Total Energy Expenditure by Performance Sections for the Active Workstation

	N	Mean (kcal/hr)	Std. Deviation (kcal/hr)	Min (kcal/hr)	Max (kcal/hr)
Active Workstation Section 1	14	109.1089	21.3369	77.0775	155.0512
Active Workstation Section 2	14	113.7351	21.7234	80.3909	154.155
Active Workstation Section 3	14	115.7706	21.114	82.129	157.2918

The results of the statistical analysis of the energy expenditures for the performance sections obtained for the seated and active workstations are presented in Table 3.35. While the means of the energy expenditures by section for the seated workstations (μ_1 = 98.43, μ_2 = 96.08, μ_3 = 97.34) were steady, those for the active workstation (μ_1 = 109.1, μ_2 = 113.73, μ_3 = 115.77) showed that participants` energy expenditures increased across sections.

Table 3. 35 Statistical Test Results for the Total Energy Expenditure (Friedman Test)

Test Statistics[a]	Seated Workstation	Active Workstation
N	14	14
Chi-Square	.691	14.714
df	2	2
Asymp. Sig.	.708	.001

a. Friedman Test

For the performance portion, the energy expenditure trials for the seated workstation stayed constant, while for the active workstation the energy expenditures by section increased linearly over time. After statistical testing by the Friedman repeated-measures test, a significant difference was found for the active workstation ($p = 0.001$) but not for the seated workstation ($p = 0.708$) (see Table 3.35).

To explain participants` energy expenditures during the cognitive portion (i.e., the seated position at each workstation), descriptive statistics for the energy expenditure during the last section of each condition are presented in Table 3.36.

Table 3. 36 Descriptive Statistics for the Total Energy Expenditure of Cognitive Section by Workstations

	N	Mean (kcal/hr)	Std. Deviation (kcal/hr)	Min (kcal/hr)	Max (kcal/hr)
Seated Workstation Section 4 (Cognitive Part)	14	90.4371	17.2736	66.4854	121.0295
Active Workstation Section 4 (Cognitive Part)	14	94.0382	18.2658	69.90749	128.343

This data was tested by the Wilcoxon signed rank test in order to determine whether there were any significant differences. The results of this statistical testing, including Z-score and p-value, are shown in Table 3.37.

Table 3. 37 Statistical Test Results for the Total Energy Expenditure of Cognitive Section (Wilcoxon Signed Rank Test)

Test Statistics[a]	Active WS Energy Expenditure – Seated WS Energy Expenditure
Z	-1.915[b]
Asymp. Sig. (2-tailed)	.056

a. Wilcoxon signed ranks test

b. Based on negative ranks

The results of the statistical analysis of the energy expenditures during the cognitive portion that were obtained for each workstation are presented in Table 3.37. The means of participants` energy expenditures for the two workstations show that participants burned 4 more kilocalories per hour after using the active ($\mu = 94$) rather than seated ($\mu = 90$) workstation. When this was tested statistically by the Wilcoxon signed rank test, no significant difference could be found ($p = 0.056$) for the energy expenditure during the cognitive portion (see Table 3.37).

3.4 Questionnaires

In addition to the performance and cognitive tests and energy expenditure data, participants` occupational and daily activity data, as well as data related to the feasibility and acceptability of using an active workstation were collected via the OSPAQ and the FAAWQ. To interpret the results of these questionnaires, the data obtained were made meaningful and correlated.

3.4.1 Occupational Sitting and Physical Activity Questionnaire

The OSPAQs were distributed to collect data about the sedentary time and physical activity level of each participant. The data were presented as means with standard deviations, and maximum and minimum values.

Table 3. 38 Descriptive Statistics for the Occupational Sitting and Physical Activity Questionnaire

	Mean ± Standard Deviation	Max	Min
Workhours/Day	7.64 ± 1.67	10	5
Workdays/Week	5.64 ± 0.72	7	5
Sitting %	73.21 ± 15.07	100	50
Standing %	13 ± 8.82	30	0
Walking %	9.43 ± 5.73	20	0
Heavy Labor %	4.36 ± 4.89	10	0

Descriptive statistics for participants` workhours per day, and days worked per week, and percentages of time spent sitting, standing, walking, and engaging in heavy labor or physically demanding tasks on a typical workday are presented in Table 3.38.

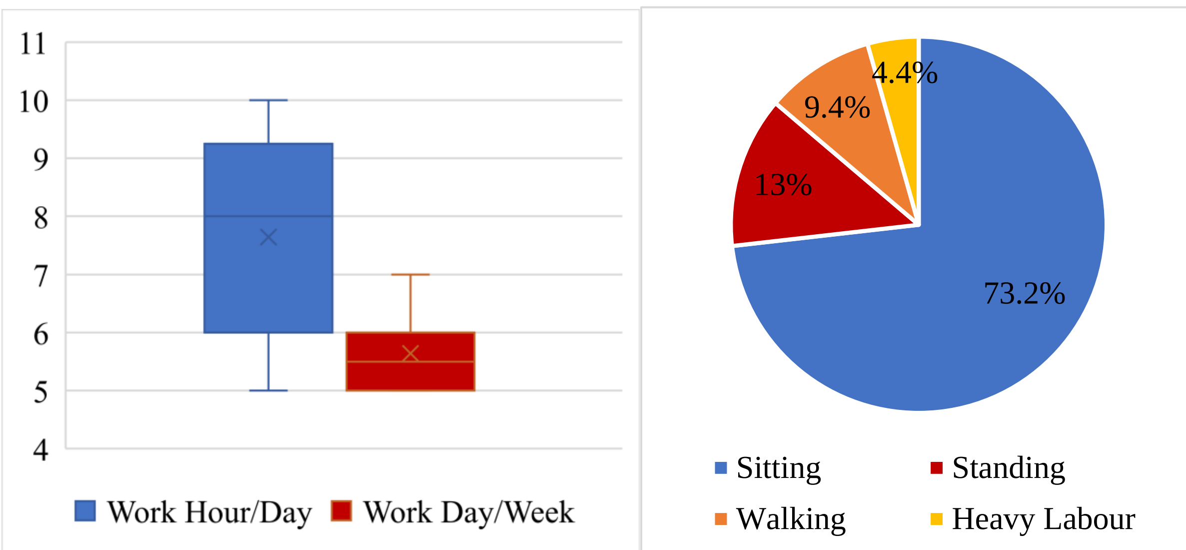

Figure 3. 24 a) Participants' Work Periods, and b) Behavior While Working

In Figure 3.24a, boxplots show the participants` work-hours per day (blue box) and workdays per week (red box). In Figure 3.24b, a pie chart illustrates the averages of the participants` percentages of the time spent sitting, standing, walking, and engaging in heavy labor or physically demanding tasks on a typical workday.

Based on the data collected from the participants, the average values of participants` total hours spent sitting, standing, and walking hours per week for a typical work week were determined.

Table 3.39 shows how these weekly hours might change if they used the “20-8-2” pattern at an active workstation.

Table 3. 39 Participants’ Reported and Calculated Behavior

	Regular Workstation (Reported by Participants)	20-8-2 Pattern at Active Workstation
Workhours/Week	43.28 ± 4.9	
Sitting Hours/Week	33.81	28.85
Standing Hours/Week	5.19	11.54
Walking Hours/Week	4.28	2.88

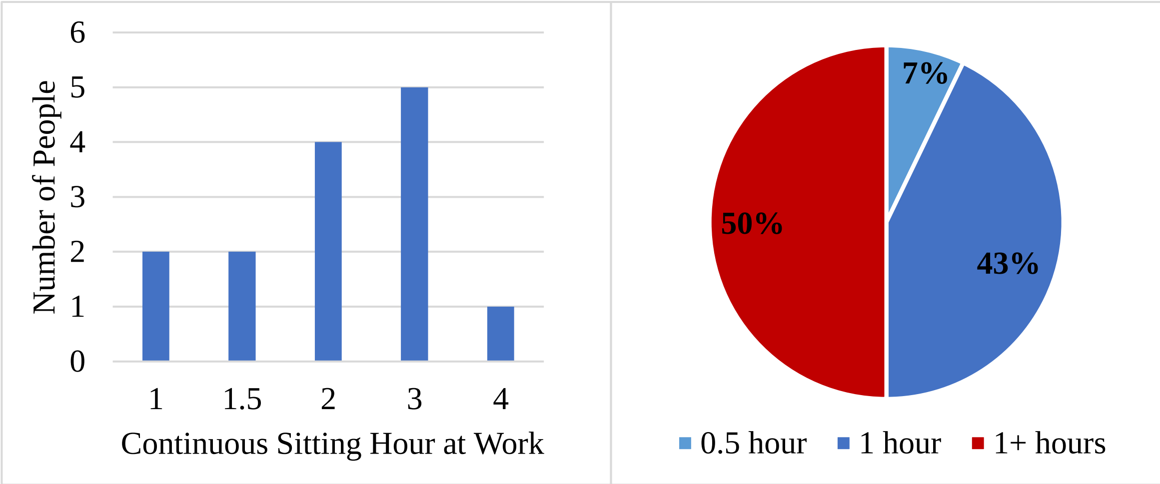

Figure 3. 25 a) Time Spent in Continuous Sitting at Work, and b) Max Continuous Sitting Time

The descriptive statistics for participants` total sitting time per week day and weekend day, daily sleeping hours, and physical activity time and days per week are presented in Table 3.40.

Table 3. 40 Descriptive Statistics for Participants' Daily Behavior

	Mean ± Standard Deviation	Max	Min
Sitting Hours/Weekday	8.36 ± 2.49	14	5
Sitting Hours/Weekend Day	8.28 ± 2.96	12	5
Sleeping Hours/Weekday	7.07 ± 1.26	10	4.5
Sleeping Hours/Weekend Day	8.36 ± 0.83	10	7
Activity Days/Week	3.43 ± 1.5	6	1
Activity Hours/Day	0.74 ± 0.24	1	0.5

3.4.2 Feasibility and Acceptability of Active Workstation Questionnaire

The FAAWQs were distributed to collect participants` feedback on their experience with the "20-8-2" time regime (i.e., 20 minutes sitting, 8 minutes standing, 2 minutes walking) at the active workstation. Data were presented as means with standard deviations and maximum and minimum values. The questionnaire, first asked participants to rate their overall experience at the active workstation, compare their ability to work at the active rather than regular workstation, and evaluate the "20-8-2" pattern at the active work station on a scale from worst (1) to best (10). The descriptive statistics for participants` overall work rate, ability to work, and impression of the "20-8-2" pattern at an active work station are presented in Table 3.41 and Figure 3.26.

Table 3. 41 Descriptive Statistics for Participants' Evaluation of the Active Workstation and "20-8-2" Pattern

	Mean ± Standard Deviation	Max	Min
Overall Experience with the Active Workstation	8.78 ± 0.94	10	7
Ability to Work at the Active Workstation	8 ± 1.51	10	5
Overall Experience with the "20-8-2" Pattern at the Active Workstation	9 ± 0.88	10	7

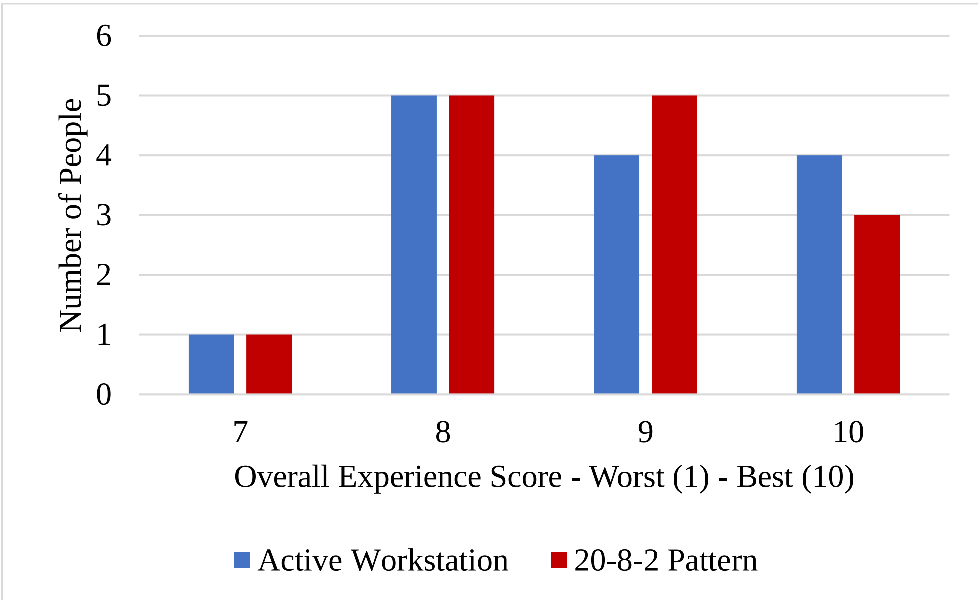

Figure 3. 26 Distribution of Overall Experience Scores

In the second part of the questionnaire, 18 questions answered via a five-point Likert-type scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree) were used to assess participants' attitudes toward the use of the active workstation and "20-8-2" pattern in a work environment, and their feelings on their potential use in participants` work and/or daily lives. The average scores were calculated for each question (see Figure 3.27).

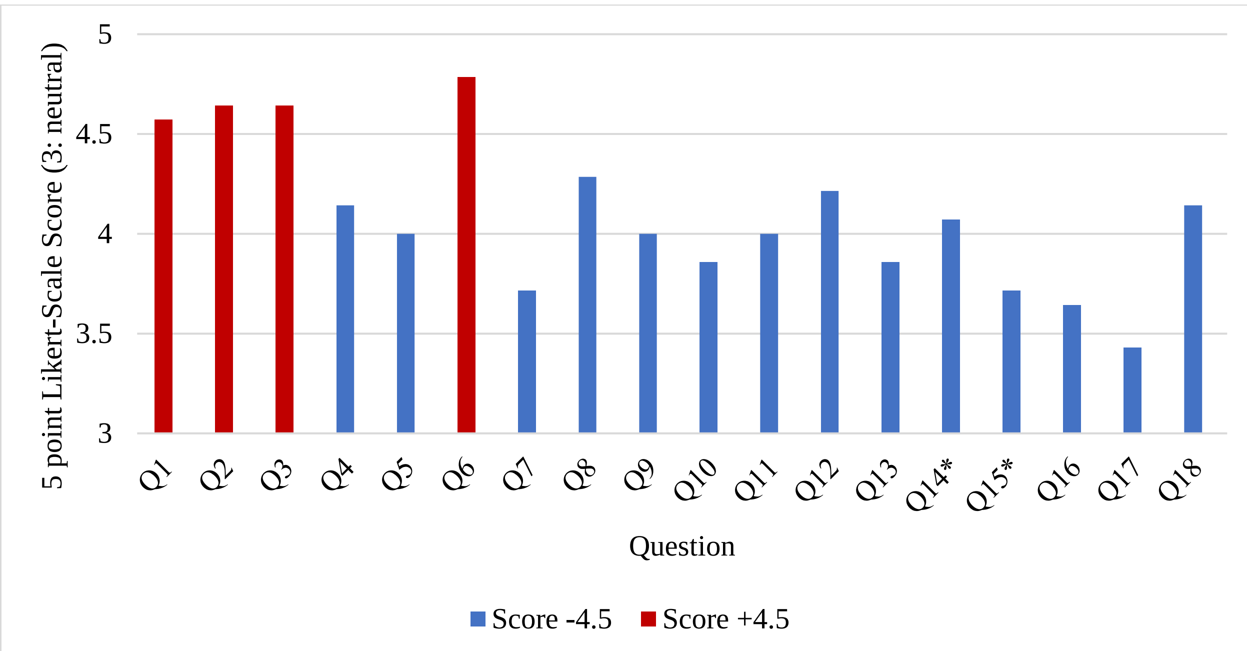

Figure 3. 27 Average Score Distribution by Question (*Reverse Wording Question)

Using the questionnaire results, a score was calculated or the average perception level of each participant. Two of the 18 questions were reverse worded, so these were reverse scored when calculating the total perception score. The overall perception scores for using the active workstation were calculated for each of the 14 participants (see Figure 3.28). Participants were grouped by the amount of maximum time they sitting without any break at work (i.e., less than 1 hour and more than 1 hour in total) (see Figure 3.28).

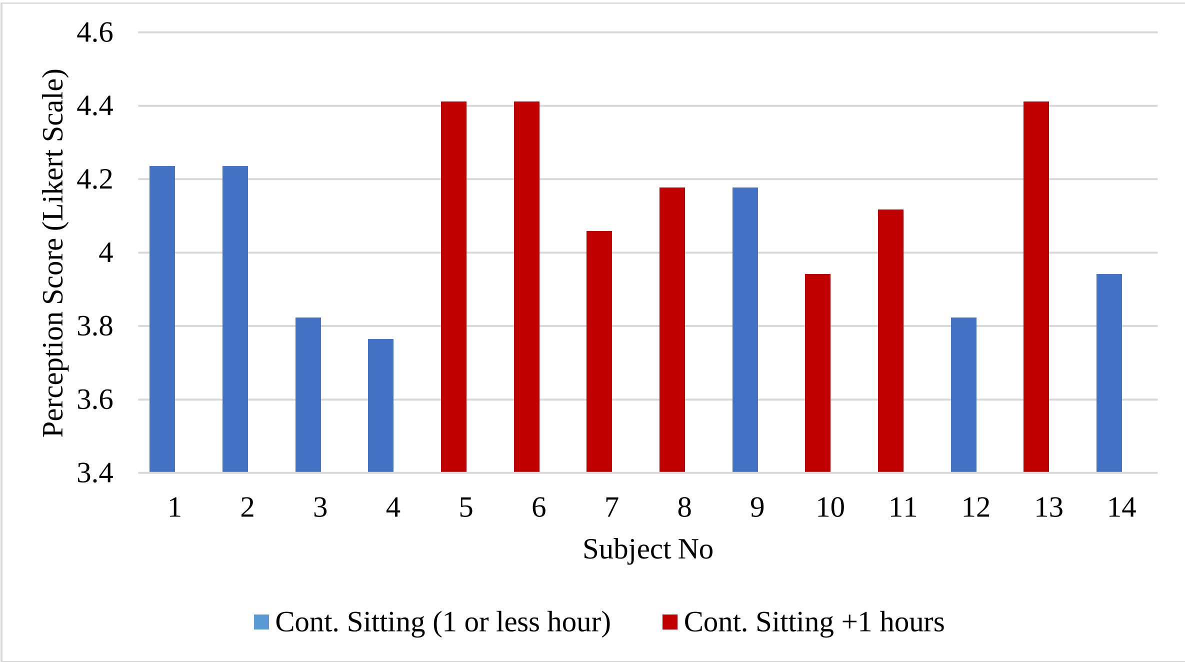

Figure 3. 28 Distribution of Overall Perception Score by Participant

4. DISCUSSION

To our knowledge, this research represents the first study using a crossover repeated measurements design to examine the effects of using the “20-8-2 pattern” at an active workstation on task and cognitive performance. Across the sit-stand-walk transaction research area, there are a wide variety of study designs and cognitive and performance outcome measures, which makes it difficult to directly compare our results those of similar studies. Therefore, the findings in this research will be important to workplace and educational facilities attempting to implement the sit-stand-walk pattern at active workstations. By using the “20-8-2” pattern, it is expected that a combination of changing both posture and energy expenditure (i.e., standing and slow-pace walking) will produce pronounced results.

Active workstations increase daily motion and potentially represent a suitable solution for enhancing physical activity in an office environment. The different patterns of standing and walking seen in the workplace support the notion that the work environment should provide office workers with less sitting time and more physical activity. When participants` typical sedentary time that that calculated by their’ workhours per week as reported in the OSPAQ compared with that after using the “20-8-2” pattern at an active workstation, the results showed that there was an approximately 5-hour decrement in sitting and 6-hour increment in standing time per workweek (see Table 3.38). It is clear that reducing work-associated sitting time by implementing the “20-8-2” pattern at active workstations could serve as an important means of reducing office workers` sedentary sitting time and the associated health risks.

There might be concerns regarding the influence of using the “20-8-2” pattern at active workstations on task and cognitive performance. The task performance section of the study part, used typing, math, and word search tasks to measure work performance at an active workstation. The use of repetitive measurements in the performance section of this research allowed for the researcher to observe changes in task performance over time at each type of workstation. For the performance test battery, it was found that the "20-8-2" pattern had an effect on task performance, but this was no significant for the overall task performance score between the seated and active workstations (see Tables 3.2, 3.7, and 3.12). However, the results of the section-based task performances analysis show that using the "20-8-2" pattern at an active workstation resulted in a significant linear increase for each task across sections (see Tables 3.5, 3.10, and 3.15). In addition, the position for the word search task was different from those of the typing and math tests for each workstation; the results of the word search task in the 8-minute standing interval reveal that there is a significant effect from using the active workstation on search task performance. This evidence shows that use of the "20-8-2" pattern at an active workstation will not negatively influence office workers` overall task performance, and may actually enhance it. It can clearly be seen from these section-based results that, after two sections of the performance portion, participants became accustomed to using the "20-8-2" pattern at the active workstation and their performance increased. There was an increase in performance in those tasks that required fine motor skills such as typing, math, and word searching at the active workstation. However, working at the seated workstation caused fatigue for participants and their performance decreased. These findings suggest that the addition of a slow-paced walking break and standing task to each the 30-minute work period consisting primarily of work-related tasks would not have a negative effect on performance.

The outcome measures used for cognitive performance used in this study were based on test scores and response times. Where many previous studies on active workstation use have only employed one or more cognitive tests (at most), the present research is the first to use the "20-8-2" pattern in an active working environment to perform a battery of cognitive tests. This study used five different tasks to measure two of the main components of cognitive performance: the working memory, short-term memory and level of attention. The findings from the data obtained from the cognitive test battery, test scores, and response time measures were consistent for each workstation and showed no difference in cognitive performance when performing in a seated position under each condition (see Tables 3.18, 3.21, 3.24, 3.27, and 3.30). To elaborate, it can be seen from the results that performing a cognitive task after using "20-8-2" pattern for a period of time likely caused response times and response error to decrease but there were only insignificant differences between using the active and seated workstations (see Tables 3.7 and 3.8). The present study found that using active workstation with the "20-8-2" pattern for a period of time did not have a negative effect on cognitive performance in terms of short-term memory and level of attention.

Active workstations increase daily energy expenditure and potentially represent a suitable solution for enhancing physical activity in an office environment. The SenseWear energy expenditure data collected in this study show the importance of active workstation usage for office workers. The current research found a significant difference between the energy expended at seated and active workstations in an office environment. The results show an average significant increase of 14 kilocalories per hour (112 kcal per 8-workhour) from using an active rather than seated workstation (see Table 3.32). Office workers will burn off approximately 3,500 calories more than what they consume, by using the regular workstation for one month, which means they will avoid gain 1 pound per month. Another result of this study is the determination that using the "20-8-2" pattern produced a significant linear increment in energy expenditure over time when using an active workstation (see Table 3.35). The three successive performance sections showed that using the “20-8-2” pattern at the active workstation enabled office workers to remain active, increasing their energy expenditure over time (see Table 3.34). It can clearly be seen the addition of 2 minutes of slow-paced walking and 8 minutes of standing to each 30-minute time period will have a positive effect on energy expenditure.

In terms of the feasibility and acceptability data for the active workstation obtained from the associated questionnaire data, this study produced important results; comments from participants were positive with regards to their use of the active workstation. Participants offered positive feedback regarding their experience with the active workstation and using the “20-8-2” pattern (see Figure 3.26). Questionnaire data, however, may not be the best representation of results because the data are self-reported. Likert scale-type questions were used to calculate overall scores for each question receiving an average score on scale of 1 to 5. From Figure 3.27, it can be seen that of the eighteen questions with scores high than 3 (neutral). It was determined that participants` comfort levels were not negatively affected when using the active workstation, as indicated by answers scored above an average 4.5-points (see Figure 3.27). These questions (i.e., questions 1,2,3,and 6) were: “The active workstation is easy to use,” “I felt comfortable using the active workstation,” “I felt comfortable using the 20:8:2 time regime at the active workstation,” and “I felt comfortable completing computer-related tasks while using the active workstation.” These results indicate that office workers' comfort levels did not decrease when they use the active workstation. In addition, participants who sitting more than one hour without any breaks at work (as compared to those with less than one hours) gave higher total scores to their perception of the active workstation (see Figure 3.28). This result shows that participants who continued to passively sitting at work without any breaks were more likely to find the active workstation useable. This finding reveals the acceptability of the active workstation to office workers who are accustomed used to prolonged sitting while at the office.

The results of this study are novel; however, there are several potential limitations for this research. First, there was a small sample size (n = 14). The participants were young adults aged 22 to 35 with no chronic health problems. More participants and a larger age span within the defined parameters would increase the generalizability of the results. Also, regarding the intellectual capacity of participants as determined from the GHIQ, there were more highly educated participants than was expected (see Figure 2.1). Adults with full-time predominantly sedentary employment are more likely to be older, with average educations and less physically fit than the sample used in this study. Experiment days could also be defined with stronger procedure restrictions. Two days with exactly seven days in between and measurements only at 10 am and 2 pm might not represented the actual attitudes of real office workers. Since this was an acute laboratory study, the results may not present the chronic or cumulative effects that changes in posture and energy expenditure might have on office workers' task and cognitive performance. Another limitation of this study is that participants were tested at only one walking speed (2.5 mph) and not at a speed adjusted to each individual. It is possible that a slower or faster walking speed might have a different effect on task and cognitive performances.

Future research could focus on observing possible postural benefits from using the "20-8-2" pattern at an active workstation versus all-day sitting in an office environment. The use of different cognitive tests and tasks such as proof-reading, word processing, creativity-based activities, etc. could also be utilized to observe the "20-8-2" pattern at an active workstation. Additionally, future research could elaborate upon the cognitive performance results of the present work, revealing the specific aspects of attention, short-term memory, and working memory that use of an active workstation might improve. It is possible that additional cognitive effects might emerge after increased exposures, and future research could consider the cognitive changes associated with periods of worktime spent at an active workstation. While the times for the sit-stand-walk pattern were predetermined for the current study, future research should investigate whether using different patterns affect task and cognitive performance or if there is a certain amount of standing and moving time recommended for the most beneficial results in an office environment. Another area of future research could specifically target overweight/obese participants in order to test other outcomes of interest. Overall, future research should focus on the optimal durations for sitting, standing, and walking and the number of cycles throughout the day that will produce the most health benefits.

5. CONCLUSION

Today's lifestyle leads us to spend more of our time in a sitting position while at work. Therefore, active workstations have been designed with standing desks that reduce the amount of time office workers spend sitting. However, long-term standing at the office may also have negative effects on office workers. To balance the time spent sitting and standing at the office, an active workstation could be used with a sit-stand-move pattern. The 20-8-2 pattern was recommended by Alan Hedge, Professor of Ergonomics at Cornell University, as a way to balance these times for office workers. The purpose of this working principle is to balance movement and sitting time so that at least 2 hours is spent standing and 30 minutes walking in a 7.5-hour workday.

This study appears to be the first to comprehensively assess how task and cognitive performance are affected by using the “20-8-2” method at an active workstation. This was achieved by using three different tasks and five cognitive tests based on attention and short-term memory, along with a robust study design and intervention comparable to a typical workstation. The results show that using the “20-8-2” pattern at an active workstation will not impair task and cognitive performance. In addition, using the “20-8-2” pattern over time seems to have a positive effect on task performance. Also, the “20-8-2” pattern at an active workstation did not appear to cause a decrease in attention or short-term memory or an increase in stress or musculoskeletal discomfort, and participants provided positive quantitative comments on questionnaires about their active workstation use.

The present study demonstrates significant differences between energy expenditure when using the “20-8-2” pattern at an active workstation versus sitting at a typical workstation. This research provides evidence that using an active workstation may be beneficial as a means of increasing the total energy expenditure and decreasing sedentary time. Since active workstations are an effective method of decreasing sitting behavior in office workers, it may be beneficial for employers to add this type of workstation to their office environment. Also, it may be beneficial to get feedback from computer and/or wearable devices for monitoring the pattern in an active workstation. Overall, it is clear that reducing work-associated sitting behavior and adding standing and short break times could be an important means of reducing people's sedentary sitting time while at the office, via the implementation of the "20-8-2" pattern at active workstations.

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APPENDIX A

RECRUITMENT EMAIL

PARTICIPANTS NEEDED!

Howdy,

You are invited to take part in a research study on **'understanding whether or not the using time regime in a sit-stand workstation will improve the task and cognitive performance`** being conducted by researchers in Texas A&M Health Science Center School of Public Health. Participants will be asked to complete questionnaires and perform computerized tasks that involve typing, word searching, math and cognitive tests while using active workstation.

The study requires 2 sessions to be completed on different days. These sessions are about 2 and half hours. We will reimburse individuals for parking, and you will be compensated for your time. You will be paid $50 ($25/session) at the end of two sessions for being in this study. The records of this study will be kept private. No identifiers linking you to this study will be included in any sort of report that might be published.

Eligibility criteria:

1. You are between the ages of 22 and 35, inclusive
2. You speak English
3. You are healthy (no acute or chronic disease)
4. You have normal or corrected-to-normal (glasses or contacts) visual acuity and normal color vision

Your participation is greatly appreciated!
If you are interested in participating, please contact Gulberg Ergin (gulberg@tamu.edu) for more study information.
Thank you for your time and consideration!

Sincerely,
Gulberg ERGIN
Graduate Student - MSc Safety Engineering
Texas A&M Health Science Center School of Public Health

IRB Number: IRB2019-0321D

APPENDIX B

PARTICIPANT INFORMATION SHEET

TEXAS A&M UNIVERSITY HUMAN SUBJECTS PROTECTION PROGRAM

INFORMATION SHEET

Effects of the 20:8:2 Time Regime at Sit-Stand Workstation on Task Performance and Cognitive Function

You are invited to take part in a research study being conducted by *Dr. Mark E. Benden and Gulberg Ergin*, a researcher from Texas A&M University. The information in this form is provided to help you decide whether or not to take part. If you decide you do not want to participate, there will be no penalty to you, and you will not lose any benefits you normally would have.

Why Is This Study Being Done?

The purpose of this study is to identify whether the use of the “20:8:2” pattern at sit-stand workstation will affect the task and cognitive performance of the office workers.

Why Am I Being Asked to Be in This Study?

You are being asked to be in this study because you are regularly working in sedentary office environments and not having any experience in sit-stand workstations.

Inclusion criteria are being healthy people (no acute or chronic diseases), aged 22–35 years, regularly working in sedentary office environments, not having any experience in sit-stand desk, regular computer users, knowing English language and consented to participate.

Exclusion criteria are having any current or previous lower limp injuries, pre-hypertension and/ or pre-diabetes, having known coronary artery disease, or orthopedic limitation for performing physical activity, color blindness or visual impairments that had not been corrected.

How Many People Will Be Asked to Be in This Study?

Approximately 15 people will participate in this study locally.

What Are the Alternatives to being in this study?

The alternative to being in the study is not to participate.

What Will I Be Asked to Do in This Study?

You will perform the test battery consisting of task performance and cognitive function test. While doing these test batteries, you will experience the active workstation with using sit-stand desk. We expect that you will be in this research study for 5 hours and includes 2 visits. These 2 visits will last about 2 and half hours, total 5 hours.

Two different experimental conditions that are tested with the same participants are designed. A within participants experimental design is used to compare study participants' ability to perform the performance task and the cognitive task under 2 experimental conditions: while seated, while using the "20:8:2" pattern (20 minutes sitting, 8 minutes standing, 2 minutes walking) at the active workstation. The active work station that is a sit-stand desk that could be adjusted to either a sitting or a standing height is used in this study. This sit-stand desk is adjusted for an ergonomically correct position for each participant. During these two experiment conditions, the participants will perform the test battery consisting of task performance and cognitive tests. While doing this test battery, they will experience the active workstation with using sit-stand desk.

Are There Any Risks to Me?

The things that you will be doing are no more than risks than you would come across in everyday life. The estimated risks are the stress may be caused by the cognitive test and the fatigue that may occur as a result of sit-stand workstation. Should the sit-stand workstation cause fatigue or the cognitive test becomes distressing to you, it will be terminated immediately.

Will There Be Any Costs to Me?

Aside from 5 hours, there are no costs for taking part in the study.

Will I Be Paid to Be in This Study?

You will be paid $50 ($25/session) at the end of two sessions for being in this study.

Will Information from This Study Be Kept Private?

The records of this study will be kept private. No identifiers linking you to this study will be included in any sort of report that might be published. Research records will be stored securely and only investigators will have access to the records. Information about you will be stored in computer files protected with a password.

Information about you will be kept confidential to the extent permitted or required by law. People who have access to your information include the Principal Investigator and research study personnel. Representatives of regulatory agencies such as the Office of Human Research Protections (OHRP) entities such as the Texas A&M University Human Subjects Protection Program may access your records to make sure the study is being run correctly and that information is collected properly. Information about you and related to this study will be kept confidential to the extent permitted or required by law.

Who may I Contact for More Information?

You may contact the researcher Gulberg Ergin, to tell her about a concern or complaint about this research at +1.979.402.6281 or gulberg@tamu.edu. You may also contact the advisor of the researcher Dr. Mark E Benden at mbenden@sph.tamhsc.edu.

For questions about your rights as a research participant; or if you have questions, complaints, or concerns about the research, you may call the Texas A&M University Human Subjects Protection Program office at (979) 458-4067 or irb@tamu.edu.

What if I Change My Mind About Participating?

This research is voluntary and you have the choice whether or not to be in this research study. You may decide to not begin or to stop participating at any time. If you choose not to be in this study or stop being in the study, there will be no effect on your student status, medical care, employment, evaluation, relationship with Texas A&M University, etc.

Any new information discovered about the research will be provided to you. This information could affect your willingness to continue your participation.

By participating in the experiments, you are giving permission for the investigator to use your information for research purposes.

Thank you.

Ms. Gulberg ERGIN
Graduate Student

APPENDIX C

PARTICIPANT CONSENT FORM

TEXAS A&M UNIVERSITY HUMAN RESEARCH PROTECTION PROGRAM

INFORMED CONSENT DOCUMENT

Title of Research Study: Effect of the "20:8:2" Pattern at Sit-Stand Workstation on Task Performance and Cognitive Function

Investigator: Principle Investigator: Dr. Mark E Benden / Researcher: Gulberg Ergin

Supported By: This research is supported by Texas A&M University.

Why are you being invited to take part in a research study?

You are being asked to participate because you are regularly working in sedentary office environments and not having any experience in sit-stand workstations.

Inclusion criteria are being healthy people (no acute or chronic diseases), aged 22–35 years, regularly working in sedentary office environments, not having any experience in sit-stand desk, regular computer users, knowing English language and consented to participate.

Exclusion criteria are having any current or previous lower limp injuries, pre-hypertension and/or pre-diabetics, having known coronary artery disease, or orthopedic limitation for performing physical activity, color blindness or visual impairments that had not been corrected.

What should you know about a research study?

- Someone will explain this research study to you.
- Whether or not you take part is up to you.
- You can choose not to take part.
- You can agree to take part and later change your mind.
- Your decision will not be held against you.
- You can ask all the questions you want before you decide.

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, talk to the researcher Gulberg Ergin at +1-979-402-6281, or by email at gulberg@tamu.edu.

You may also contact the advisor of the principle investigator Dr. Mark E Benden at mbenden@sph.tamhsc.edu.

This research has been reviewed and approved by the Texas A&M Institutional Review Board (IRB). You may talk to them at 1-979-458-4067, toll free at 1-855-795-8636, or by email at irb@tamu.edu., if

- You cannot reach the research team.

Your questions, concerns, or complaints are not being answered by the research team.

- You want to talk to someone besides the research team.
- You have questions about your rights as a research participant.
- You want to get information or provide input about this research.

Why is this research being done?

One of the most important problems faced by the majority of office workers is to work prolonged sitting time. As it is known, prolonged sitting increases the risk of heart disease, obesity, diabetes, cancer and even premature death. According to the experts, to minimize these problems and to have a healthy life in the office sitting time need to be reduced. However, experts state that prolonged standing can also cause health problems. Therefore, office workers should try to establish a balance between sitting, standing and movements.

It has been researched prolonged sitting and standing affect human health and cognition. In comparison with research on standing work station, the effects of sit-stand-walk transitions on cognitive performance have not been well studied and the cognitive performance effects of the active workstation (positive or negative) remain uncertain. Therefore, the purpose of the study is to research the effect of “20:8:2” pattern use at sit-stand workstation on measures of cognition, attention, short-term memory and task performance.

How long will the research last?

We expect that you will be in this research study for 5 hours and includes 2 visits. These 2 visits will last about 2 and half hours, total 5 hours.

How many people will be studied?

Approximately 15 people will participate in this study locally.

Will participants be paid to be in this study?

You will be paid $50 ($25/session) at the end of two sessions for being in this study.

What happens if I say "Yes, I want to be in this research"?

You will perform the test battery consisting of task performance and cognitive function test. While doing these test batteries, you will experience the active workstation with using sit-stand desk. Your participation in this study will last up to 5 hours and includes 2 visits. These 2 visits will last about 2 and half hours. All these procedures, you will interact with the researcher Gulberg Ergin in Texas A&M Health Science Center School of Public Health 212 Adriance Lab Rd, College Station, TX 77843.

Two different experimental conditions that are tested with the same participants are designed. A within participants experimental design is used to compare study participants' ability to perform the performance task and the cognitive task under 2 experimental conditions: while seated, while using the "20:8:2" pattern (20 minutes sitting, 8 minutes standing, 2 minutes walking) at the active workstation. The active work station that is a sit-stand desk that could be adjusted to either a sitting or a standing height is used in this study. This sit-stand desk is adjusted for an ergonomically correct position for each participant. During these two experiment conditions, you will perform the test battery consisting of task performance and cognitive tests. While doing this test battery, you will experience the active workstation with using sit-stand desk.

What happens if I do not want to be in this research?

It is totally up to you to decide to be in this research study. Participation in this study is voluntary. You are free to withdraw or discontinue participation at any time.

What happens if I say "Yes", but I change my mind later?

You can leave the research at any time and it will not be held against you.

Is there any way being in this study could be bad for me?

There are no known major risks associated with participation in the study and no more than risks than you would come across in everyday life. The estimated risks are the stress may be caused by the cognitive test and the fatigue that may occur as a result of sit-stand workstation. Should the sit-stand workstation cause fatigue or the cognitive test becomes distressing to you, it will be terminated immediately.

What happens to the information collected for the research?

Efforts will be made to limit the use and disclosure of your personal information, including research study and other records, to people who have a need to review this information. We cannot promise complete privacy. Organizations that may inspect and copy your information include the TAMU HRPP/IRB and other representatives of this institution.

I will protect the confidentiality of your research records by coded. No identifiers linking you to this study will be included in any sort of report that might be published. The records of this study will be kept private. The records of this study will be kept private. No identifiers linking you to this study will be included in any sort of report that might be published. Research records will be stored securely and only investigators will have access to the records. Information about you will be stored in computer files protected with a password.

Your signature documents your permission to take part in this research.

Signature of subject | Date

Printed name of subject

Signature of person obtaining consent | Date

Printed name of person obtaining consent

APPENDIX D

TYPING TEXTS

Text #1

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Text #2

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Text #3

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APPENDIX E

GENERAL HEALTH INFORMATION QUESTIONNAIRE
(Privileged and Confidential)

1. General Information

Gender: Female ☐ Male ☐ Prefer not to respond ☐

Age:________________________________

Native Language:_____________________

Education:

Bachelor's Degree	☐	Post Graduate Certificate/Diploma	☐
Master`s Degree	☐	Doctoral Degree	☐
Diploma Certificate	☐	Secondary School (Classes 8-10-12)	☐
Other	☐		

If other, please explain:____

2. Body Composition

Current Height:__________cm/inches **Current Weight:**_________kg/pounds

3. Health Details

Please answer the questions below. Please circle to select Y(YES) / N(NO).
If yes, please give details in the space provided or continue on separate sheet, if necessary.

- Do you have poor health? Y N
  If yes, please explain:____
  ____

- Do you have acute or chronic diseases? Y N
  If yes, please explain:____

- Do you have coronary artery disease? Y N
  If yes, please explain:

- Do you have pre-hypertensive (blood pressure is >140/90 mm Hg)? Y N
  If yes, please explain:

- Do you have pre-diabetes (Type 1 or 2) (impaired fasting glucose 6.1 to 6.9 mmol/L or oral glucose tolerance test 7.8 to 11.0 mmol/L)? Y N
  If yes, please explain:

- Do you have high cholesterol (>5.2 mmol/L)? Y N
  If yes, please explain:

- Do you have a heart, circulatory problem, or chronic chest problem? Y N
  If yes, please explain:

- Do you have anxiety, depression or trouble with your nerves? Y N
  If yes, please explain:

- Do you have orthopedic limitation that may affect your physical activity? Y N
  If yes, please explain:

- Do you have any musculoskeletal problems or recent injuries (muscle, bone, or joint)? Y N
  If yes, please explain:

- Do you have a history of falls? Do you use a walking aid? Y N
  If yes, please explain:____
  ____

- Do any of your medications cause side effects that might affect your physical (weakness, drowsiness, dizziness, lack of coordination, muscle or joint pain)? Y N
  If yes, please explain:____
  ____

- Do you have color blindness or visual impairments that had not been corrected? Y N
  If yes, please explain:____
  ____

- Do you smoke? Y N
  If yes, please state how many per day?______________________________________

- Do you drink alcohol? Y N
  If yes, please state how much per week?_____________________________________

Thank you for your help with this questionnaire.

APPENDIX F

OCCUPATIONAL SITTING AND PHYSICAL ACTIVITY QUESTIONNAIRE

1. How many hours did you work/study on your typical workday?

   ___________________ minutes/hours per days

2. During the last 7 days, how many days were you at work?

   ___________________ days

3. How would you describe your typical work day in the last 7 days? (This involves only your work day, and does not include travel to and from work, or what you did in your leisure time)

a. Sitting (including driving)	________%
b. Standing	________%
c. Walking	________%
d. Heavy labour or physically demanding tasks	________%
Total	________%

Make sure this adds up to

Example:

Jane is an administrative officer. Her work day involves working on the computer at her desk, answering the phone, filing documents, photocopying, and some walking around the office. Jane would describe a typical work day in the last 7 days like this:

Sitting (including driving)	90 %
Standing	5 %
Walking	5 %
Heavy labour or physically demanding tasks	0 %
Total	100 %

4. On a typical workday, how many hours maximum do you spend in continuous sitting at work (in meeting, at workstation etc.)?

   ___________________ minutes/hours per day

5. How often do you "break up" the time you spent sitting in work?

   ☐ *(every 5 mins)* ☐ *(every 10 mins)* ☐ *(half hourly)* ☐ *(hourly)* ☐ *(more than hourly)*

   OR ☐ I did not sit for more than 30 minutes in a day

6. How much time do you usually spend sitting on a weekday?

   _____________ minutes/hours per day

7. How much time do you usually spend sitting on a weekend day?

   _____________ minutes/hours per day

8. How long do you usually sleep per day?

   _____________ minutes/hours weekday _____________ minutes/hours weekend

9. In a typical week, how many days do you do moderate-intensity (such as brisk walking) to vigorous-intensity (such as running) physical activity?

   ___________________ days per week

10. On average for days that you do at least moderate-intensity physical activity (as specified above) how many minutes do you do?

    ___________________ minutes/hours per day

11. During your leisure time, how many hours do you watch television, use a computer, read, and spend sitting quietly?

    ___________________ minutes/hours per day

12. How often do you “break up” the time you spent watching TV or using a computer during your leisure-time?

☐	☐	☐	☐	☐
(every 5 mins)	*(every 10 mins)*	*(half hourly)*	*(hourly)*	*(more than hourly)*

OR ☐ I did not sit for more than 30 minutes in a day

Thank you for your help with this questionnaire.

APPENDIX G

QUESTIONNAIRE FOR EVALUATING THE FEASIBILITY AND ACCEPTABILITY OF ACTIVE WORKSTATION

1) How was your overall experience with the active workstation, on a scale from worst (1) to best (10)?

1 2 3 4 5 6 7 8 9 10

2) How would you rate your work ability in active workstation compared to regular workstation, on a scale from worst (1) to best (10)?

1 2 3 4 5 6 7 8 9 10

3) On a scale of 1 to 10 (10 being the best), how would you rate this 20:8:2 time regime at active workstation?

1 2 3 4 5 6 7 8 9 10

4) Did your impressions of the active workstation change after using it?

☐ Yes ☐ No

If so, how and why?

____

____

____

____

5) The following questions ask you about regular and sit-stand workstation. Circle the number that most closely indicates the extent to which the item is present your idea:

	Survey Scale: **1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly Agree**					
#	**Questions**	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
1	The active workstation is easy to use	1	2	3	4	5
2	I felt comfortable using the active workstation	1	2	3	4	5
3	I felt comfortable using the 20:8:2 time regime at the active workstation	1	2	3	4	5
4	My task related attention increased while using the 20:8:2 time regime at the active workstation	1	2	3	4	5
5	The quality of my work increased while using the active workstation	1	2	3	4	5
6	I felt comfortable with computer-related tasks while using the active workstation	1	2	3	4	5
7	I felt less stress at the active workstation	1	2	3	4	5
8	I was alert while working at the active workstation	1	2	3	4	5
9	I felt calm and relaxed at the active workstation	1	2	3	4	5

	Survey Scale: 1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly Agree					
#	**Questions**	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
10	I could more focus at the active workstation than regular workstation	1	2	3	4	5
11	I felt as though I accomplish more at the active workstation than regular workstation	1	2	3	4	5
12	I was more productive while working at the active workstation than regular workstation	1	2	3	4	5
13	I felt comfortable while working the regular workstation	1	2	3	4	5
14	I find it difficult to concentrate on tasks while using the 20:8:2 time regime at the active workstation	1	2	3	4	5
15	I experienced fatigue while working at the active workstation	1	2	3	4	5
16	I would use the 20:8:2 time regime during the working day	1	2	3	4	5
17	I would use the active workstation while at home	1	2	3	4	5
18	I could recommend the active work station to colleague or friends	1	2	3	4	5

Any other comments that will benefit the development of the Active Workstation?
(Ex. change the 20:8:2 time regime, or adjusts to all heights, ergonomic, sustainable, ect.)

____
____
____
____
____

Thank you for your help with this questionnaire.