ESCOLA SUPERIOR DE SAÚDE
POLITÉCNICO DO PORTO

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Effects of Cycling Computer Workstation on Cognitive Function and Work Performance

Dissertação submetida à Escola Superior de Saúde para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Higiene e Segurança nas Organizações, realizada sob orientação científica da Professora Doutora Joana Santos, Área Técnico-Científica de Saúde Ambiental da Escola Superior de Saúde.

Novembro, 2017

Agradecimentos

Gostaria de aproveitar esta oportunidade para agradecer a algumas pessoas que foram essenciais para a conclusão desta etapa:

À Professora Doutora Joana Santos, pela partilha de todo o conhecimento científico, por toda a paciência e por todas as palavras de encorajamento. Por ter estado sempre presente e por me desafiar constantemente à procura de novo conhecimento e ao desenvolvimento de novas competências.

A todas as participantes do estudo, obrigada pelo tempo e energia dispensados.

Aos meus pais, a quem devo tudo o que sou e tenho hoje, pelo apoio incondicional e por todo o esforço para que me tornasse sempre uma pessoa melhor, quer a nível académico, quer a nível pessoal. Amo-vos!

À minha restante família, em especial aos meus avós e à minha prima Mafalda, por todo o amor, apoio constante e por acreditarem sempre em mim, seja qual for o desafio.

Ao meu namorado, por nunca ter saído do meu lado, por toda a força que muitas vezes me fez continuar e por me fazer sempre acreditar que sou capaz.

À minha companheira nesta jornada, e na vida, Ana Oliveira, por todo o apoio e por todas as vezes me tranquilizou e me encorajou. Sem ti teria sido muito mais difícil, sem dúvida!

Aos meus restantes amigos, por compreenderem toda a ausência e por estarem sempre por perto quando preciso.

Resumo

A exposição ocupacional a grandes períodos de tempo sentados tornou o local de trabalho uma oportunidade para melhorar a saúde dos adultos em geral, através da implementação de estações de trabalho ativas. O objetivo deste estudo é avaliar as diferenças no desempenho no trabalho e na função cognitiva, enquanto os participantes estão apenas sentados ou a pedalar. A amostra é constituída por 20 estudantes do género feminino, com idade entre 18 e 25 anos, com um Índice de Massa Corporal entre 18.5 – 25 kg/m^2, sem lesões músculo-esqueléticas e sem défice cognitivo, que realizaram tarefas de escritório ao computador. As participantes responderam ao questionário do Perfil de Estados de Humor em cada momento de avaliação. A velocidade e o número de erros cometidos na transcrição de um texto, a atenção seletiva, o controlo inibitório e o estado de humor foram estudados. Os resultados mostraram algumas diferenças significativas entre momentos de medição, o que pode permitir concluir que a prática e a familiarização com a tarefa são essenciais para uma melhor função cognitiva. As estações de trabalho ativas podem ser uma solução para reduzir o tempo sentado e o comportamento sedentário, sem comprometer a função cognitiva e a performance no trabalho.

Palavras-chave: Estações de trabalho ativas; Ciclo ergómetro; Atenção seletiva; Controlo inibitório; Estado de humor; Velocidade de digitação.

Abstract

Excessive occupational exposure to prolonged sitting turns workplace an opportunity to improve adult's health, through the implementation of active workstations. The objective of present study was to assess the differences in work performance and cognitive function while participants sitting or cycling. 20 female students, aged between 18-25 years, with a Body Mass Index (BMI) among 18.5-25 kg/m^2, without history of musculoskeletal complaints and with a normal cognitive function performed simulated office tasks. Participants answered the short version of the Profile Mood States (POMS) - Portuguese adaptation in each measurement. Typing speed, number of errors, selective attention, inhibitory control and mood states were studied. The results revealed some differences between measurement moments, which could allow to conclude that practice and familiarization with tasks is essential to a better cognitive function. Active workstation seems to provide a good solution to reduce sitting time and sedentary behaviour without comprise the cognitive function and work performance.

Keywords: Active workstations; Cycle ergometer; Selective attention; Inhibitory control; Mood states; Typing Speed;

Contents

List of abbreviations and acronyms

SCWT – Stroop Color and Word Test

POMS – Profile of Mood States

BMI - Body Mass Index

IPAQ - International Physical Activity Questionnaire

MMSE - Mini Mental State Examination

W – Word task

C – Color task

CW – Color Word task

T - Tension-Anxiety

D- Depression-Melancholy

H - Hostility- Anger

F- Fatigue – Inertia

V - Vigor – Activity

C - Confusion –Disorientation

TMD - Total Mood Disturbance

WPM - Words Per Minute

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I. Introduction

Modern changes in communication, transportation, domestic-entertainment technologies and workplaces are related to a substantial increase of sedentary living (Owen, Healy, Matthews, & Dunstan, 2010). Physical inactivity has been identified as the fourth leading risk factor for global mortality and considered the principal cause to coronary heart disease and stroke, diabetes, hypertension, colon cancer, breast cancer and depression (WHO, 2010).

In addition to physical inactivity, sedentary behaviour, who can be defined as any waking sitting or lying behaviour with low energy expenditure, has emerged as an independent risk factor for morbidity and mortality (Wilmot et al., 2012)

Sedentary behaviour was enhanced when the principal mode of working has become computer based (Smithi, Conway, & Karsh, 1999). This has resulted that many people sitting and be sedentary 8 hours/day which may be a substantial risk to their health (Straker, Levine, & Campbell, 2009). Prolonged time spent seated are associated with obesity, cancer, diabetes and cardiovascular diseases (Thorp, Owen, Neuhaus, & Dunstan, 2011; Wilmot et al., 2012) and with high psychological distress (i.e., depression, anxiety, stress symptoms) (Rebar, Vandelanotte, Van Uffelen, Short, & Duncan, 2014; Sanchez-Villegas et al., 2008). Being sedentary (i.e. spending a lot of time sitting) has been linked to more depressive symptoms and be engaged in screen-based sitting increased the appearance of mental disorders (Rebar et al., 2014).

Occupational exposure to prolonged sitting can account for around half of total weekly sedentary time (Parry & Straker, 2013; Wilmot et al., 2012) which makes the workplace an opportunity to decrease adults sitting time and improve health. Initiatives to reduce sitting time on workplace emerging, such as workplace-based physical activity program (Naito et al., 2008; Sjögren et al., 2005) and walking during the lunchtime.

Health promotion programmes may yield economic benefits in terms of reduced absenteeism, employee health care costs and turnover (Proper & Van Mechelen, 2008). However, the most of strategies to promote physical activity in workplaces need that employees leave their desks (Levine & Miller, 2007) and many organizations declined this programs. A system in which workers could use computers while being physically active seems to be the only viable solution for this problem and, has a resulted, active workstations appeared.

These workstations included treadmill desks, pedals or stepping fitted underneath the desks and height-adjustable workstation (Neuhaus et al., 2014) and may be used to increase low intensity physical activity in the workplace (Levine & Miller, 2007).

Several benefits of implementing active workstation have been increasingly studied both physically (Cao, Liu, Zhu, & Ma, 2016; Cox et al., 2011) and psychosocially (Thompson, Foster, Eide, & Levine, 2007), including cognitive function (Alderman, Olson, & Mattina, 2014; Ohlinger, Cox, Berg, & Horn, 2009).

Active workstations are seen as an opportunity to improve the health of working population, through, for example, the decrease of the incidence or progression of chronic disease. Moreover, there are other important psychological outcomes that may influence people's well-being and performance at work, like cognitive function, workplace performance, job satisfaction, mood states and quality of life (MacEwen, MacDonald, & Burr, 2015) and which have to be studied. It is imperative to take into account these mental health problems and changes in mood states that are emerging and influence the performance of the population in various situations (Beedie, Terry, & Lane, 2000; Lane, Whyte, Terry, Nevill, & Lane, 2005).

The main objective of this study was to evaluate the differences in work performance and cognitive function while participants sitting or cycling. To achieve this goal, specific objectives were defined:

- Compare the differences between groups (sitting and cycling) and measurement moments in cognitive function, through selective attention and response inhibition, with the application of Stroop Color and Word Test (SCWT);
- Compare the differences between groups (sitting and cycling) and measurement moments in work performance, through typing speed and number of errors, with the application of a transcription test;
- Understand the influence of an active workstation in mood states, through the application of Profile of Mood States (POMS).

II. Literature review

1. Cognitive Function and Work performance

Nowadays, people in working age spend much of their times in environments that, in addition to limiting their physical activity, also require them to sit for prolonged periods of time (Dunstan et al., 2013), with a particular focus on workplace.

Sedentary behaviour often results in physical dysfunction, which also correlates highly with mental health (Ormel, Rijsdijk, Sullivan, Van Sonderen, & Kempen, 2002). In turn, mental health and mood states influences work performance and cognitive function, since, for example, depressive symptoms are associated with reduced functional status and impaired occupational performance (Druss, Rosenheck, & Sledge, 2000).

There are essential cognitive processes for a good work performance, as is the case of executive functions. Executive function, or controlled cognition, was an important ability that manages the regulation of attention, emotions and other basic cognitive functions essentials for job performance (Alvarez & Emory, 2006; Bell & Deater-Deckard, 2007; Blair & Diamond, 2008). These functions are the combination of several cognitive processes that associate themselves in various ways to operate in different situations, which led to the development of several theories for the existence of an executive control system, such as Anderson (2002).

The executive control system (Anderson, 2002) is a conceptual framework which take the executive functions as a system divided into 4 major domains: cognitive flexibility, goal setting, attentional control and information processing (Anderson et al., 2008). as can be observed on Figure 1.

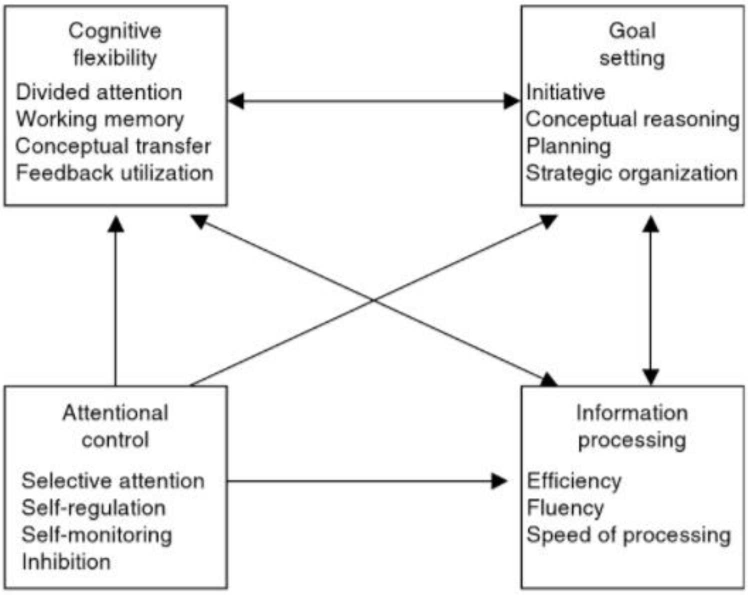


Figure 1- The executive control system. Adapted from "Assessment and development of executive function (EF) during childhood", by Anderson, P. 2002. Child Neuropsychology. 82(2). p.71. (Anderson et al., 2008).

These domains are considered independent and comprise different functions, but to operate in a functional way, there must be an interaction between them and a bidirectional relationship. In this way, they are interrelated and, together, constitute an overall control system (Anderson et al., 2008). The “cognitive flexibility” domain includes divided attention, working memory, conceptual transfer and feedback utilization. This domain is considered, according to this model, a main component of executive function and embrace the capacity to shift between response sets, develop alternative strategies, divided attention and process multiple information simultaneously. The “goal setting” field is constituted by initiative, conceptual reasoning, planning and strategic organization and comprises the ability to start an activity and devise a plan to complete the activity. The domain related to “attentional control” includes selective attention, self-regulation, self-monitoring and inhibition and concerns the capacity to selectively attend to specific stimuli and the skill to focus attention for a continued period. The “information processing” includes efficiency, fluency and speed of processing, which are essential components of response and can compromise the cognitive performance.

In previous active workstation research cognitive function was studied through the measure of divided attention and short term memory with the Auditory Consonant Trigram test (Ohlinger et al., 2009), selective attention, response inhibition (Torbeyns et al., 2016) and information processing speed (Alderman et al., 2014) with SCWT. Selective attention refers to our ability to focus on certain stimuli and process them under attentional control and, in the other hand, divided attention acts when two attention demanding tasks are performed in parallel (Salo, 2017). Response inhibition (or inhibitory control) allows to being able to control various issues, such as attention, thoughts and emotions to focus on what are more appropriated or necessary and suppressing attention to other stimuli (Diamond, 2013).

The use of active workstations to improve cognitive function has been studied, because several research indicate that physical exercise has this effect (Audiffren, Tomporowski, & Zagrodnik, 2008; Davis et al., 2011; Mcmorris, Sproule, Turner, & Hale, 2011). Tomporowski (2003) concluded that moderated levels of aerobic exercise, up to 60 minutes, improves cognitive performance by facilitating specific aspects of information processing; Dishman et al. (2006) revealed that physical activity enhances cognitive performance through the facilitation of neurogenerative, neuroadaptive and neuroprotective processes, thus improving cognition and some types of learning; Chaddock et al. (2010) and Colcombe et al. (2006) associated an increase in the volume of brain regions to the progress of cognitive functions in preadolescent children and older adults, respectively. There is limited literature studying neurophysiological benefits of physical activity on cognitive function in young adults, but the huge majority is focused on cognitive ageing.

Positive effects of physical activity in work performance were found in some studies, which indicated better academic performance in students and less absenteeism and better productivity in working population (Donnelly & Lambourne, 2011; Van Den Heuvel et al., 2005).

Work performance (or job/employee performance) was defined by “the extent to which an employee contributes to organizational effectiveness given the expectations associated with his/her work role” (Treadway et al., 2005; Zablah, Franke, Brown, & Bartholomew, 2012) and is measured thought several aspects, such as absenteeism, the work-loss days, and *presenteeism*, which is the decrement in work quality and quantity while at work (Pronk et al., 2004).

Work health promotion reduced sickness absence (Kuoppala, Lamminpää, & Husman, 2008), with emphasis in fitness programs and vigorous physical activity (Proper & Van Mechelen, 2008).

In previous active workstation research work performance was measured based on participants performance in tests that simulate work tasks, such as the Transcription test (that measure performance and speed on typing) (Straker et al., 2009), the Digital Finger Tapping Test (that measures motor control and motor speed) (Ohlinger et al., 2009) and reading and mouse tasks (that measures reading and mouse performance and reaction time) (Commissaris et al., 2014).

2. Mood states

The relation between physical exercise, mood states, cognitive function and work performance forms a cycle that cannot be broken - mood states should be improved, since it is an influence on performance, but performance may influenced mood states, as clarified in Figure 2.

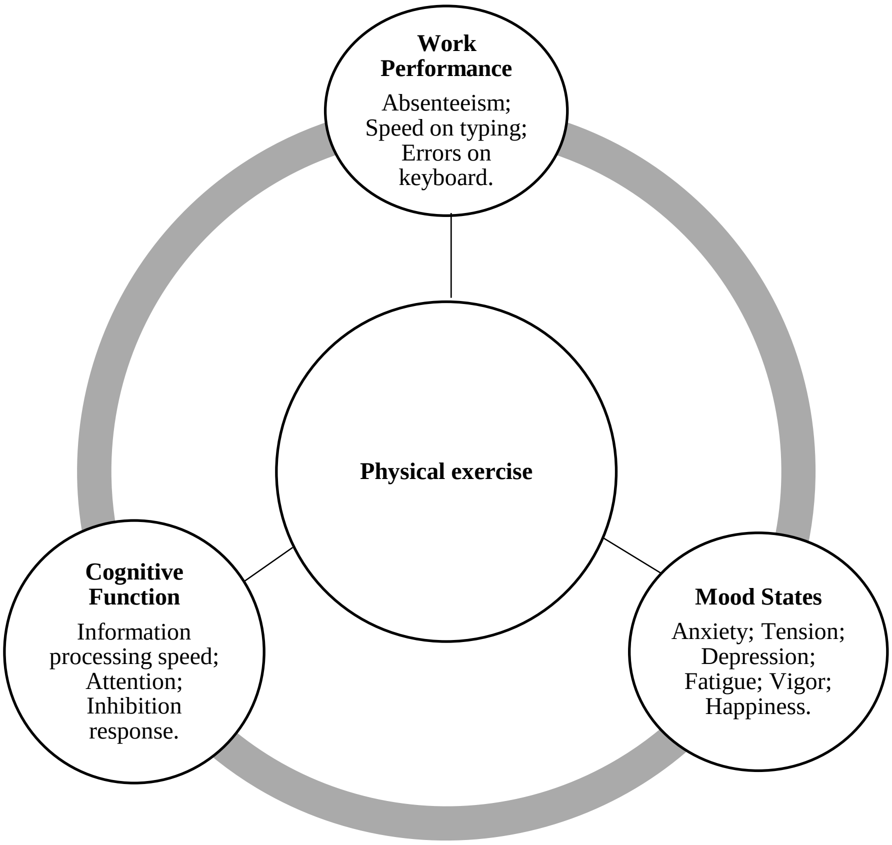


Figure 2- Relation between Physical exercise, Mood states, Cognitive Function and Work performance

If a person experienced periods of positive mood, there is evidence that it can improved task performance (Miner & Glomb, 2010). On the other hand, new working methods and the increased need to used cognitive functions, such as processing and analysing information, may have overload workers and impaired well-being and mood (World Health Organization, 2012).

Some research revealed that regular exercise can improved mood and performance (Byrne & Byrne, 1993), leading to better concentration and more resilience to stress (Coulson, Mckenna, & Field, 2008), and reduce the negatives states, such depression and anxiety (Ledwidge, 1980; Steptoe & Bolton, 1988). Individuals who exercise at least two to three times a week had experienced significantly less depression, anger and stress (Hassmén, Koivula, & Uutela, 2000).

In this way, the implementation of active workstations seems to be a solution to join everything that is necessary to combine improvement of mood states and cognitive and work performances. Implementing active workstation may be related to lower feelings of fatigue (Zeigler, Swan, Bhammar, & Gaesser, 2015) and reducing occupational sitting time, or sedentary behaviour, improving mood states (Pronk, Katz, Lowry, & Payfer, 2012).

Previous research also revealed that this mood state improvement by exercise happens due to alterations in neurotransmitter mechanisms such as norepinephrine, serotonin and endocannabinoids (Sparling, Giuffrida, Piomelli, Rosskopf, & Dietrich, 2003).

3. Active workstations

Integrating physical activity into daily life activity becomes crucial and, how people spend most of their time in the workplace (and usually larges periods of time sitting), implementing active workstation seems to be a great solution.

The concept behind these workstation is not replace daily exercise, but decrease the amount of sitting/sedentary activities while they are at work (Levine & Miller, 2007). Active workstations may be used to improved low intensity physical activity in workplace and allows employees to work at their desks while cycling or walking (Levine & Miller, 2007; Seiler, Pilcher, & Baker, 2016).

The research refers different types of workstation, such as “sit-stand” (example in Figure 3) - switch between sitting, standing and sometimes walking (Hall, Mansfield, Kay, & McConnell, 2015), and “treadmill” or “cycling workstation”, using a treadmill (John, Bassett, Thompson, Fairbrother, & Baldwin, 2009) or a cycle ergometer (Torbeyns, Bailey, de Geus, & Meeusen, 2015) while working (example in Figure 4).

Figure 3- Sit-stand workstation (Hedge, Jagdeo, Agarwal, & Rockey-Harris, 2005)

Figure 4- Walking and cycling workstations (Commissaris et al., 2014)

The type of physical activity that is most consistent with the use of an active workstation is categorized as “very light” to “light” in intensity, such as walking or cycling (Cox et al., 2011; Sliter & Yuan, 2014). This type of activity have been related to less levels of depression and enhanced psychological well-being (Netz & Wu, 2005; Wipfli, Rethorst, & Landers, 2008).

In addition, these type of workstations can influence work productivity through the simplification of a more constant and enthusiastic workforce, more attractive jobs when recruiting a new workforce and public relations advantages (Straker, Levine, & Campbell, 2009).

Effects of active workstation in physical health are very clear: weight loss (Koepp et al., 2013), increased energy expenditure (Thompson, Koepp, & Levine, 2013) and High Density Lipoprotein (HDL) cholesterol (Alkhajah et al., 2012) and reduced pain in back and neck (Pronk et al., 2012).

However, some organizations may be hesitant to implement the workstations, because walking or cycling while working requires workers to divided limited attentional or cognitive resources, which may compromise work performance and productivity (Alderman et al., 2014).

Slightly decreased in computer task performance (Straker, Levine, & Campbell, 2009) and in motor speed and motor control (Ohlinger et al., 2009) are some of the conclusions of different studies related to this subject. However, other research suggests that implementing active workstations are a solution that stimulates the practice of physical exercise and decrease the sedentary behaviour (through reducing sitting time) without any effect on cognitive function and work performance (no effects on selective attention, reading comprehension and processing speed are founded) (John et al., 2009; Ohlinger et al., 2009).

Relative to cycling workstation (that was used in this study) the results of previous research are relatively ambiguous. For example, Elmer & Martin (2014) conclude that a cycling workstation can facilitate physical activity without compromising typing performance and, in the other hand, Straker, Levine and Campbell (2009) associated intense cycling to more errors in work performance.

III. Materials and Methods

1. Participants

The participants who were selected to participate in this study was 20 female students aged between 18-25 years, with a Body Mass Index (BMI) 18.5-25 kg/m^2, without history of musculoskeletal complaints and with a normal cognitive function were selected to the study.

To define the exclusion and inclusion criteria (Table 1) was used the International Physical Activity Questionnaire (IPAQ) – short version – (Annex 1) which allowed to determine the Body Mass Index and the existence of musculoskeletal disorders and the Portuguese adaptation of Mini Mental State Examination (MMSE) (Annex 2) (Guerreiro et al., 1994) that were used to define cognitive impairment.

All processes were explained to the participants at the beginning and they signed an informed consent.

Table 1 - Inclusion and Exclusion criteria

Inclusion criteria	**Exclusion criteria**
Female Students 18-25 years of age Body Mass Index - 18.5 - 25 kg/m2 Signed informed consent	Existence of musculoskeletal disorders Existence of cognitive impairment

2. Workstation

The workstation was constructed using a cycle ergometer (Mini Bike O'Fitness FR080D) with an adjustable desk and chair (Figure 5). Participants adjusted the cycle ergometer and the table until they were sitting in a comfortable and ergonomic posture. The mini bike was affixed to the ground in order to guarantee more stability to the participant while cycling (Figure 5) and had the same workload to everyone (light mode). Cognitive and office tasks (Transcription and Stroop tests) were performed to simulate the office work, with the same computer and keyboard all over the experiment.

Figure 5- Active workstation and cycle ergometer used in present study

IV. Tests and instrumentation

1. Stroop Color and Word test

The Stroop Color and Word test was developed by John Ridley Stroop (1935) and was used to assess selective attention and inhibitory control (Alderman et al., 2014; Ohlinger et al., 2009). This test allows to evaluate the "Stroop effect" (or Stroop interference), which consists in the inhibition of automatic responses in favour of other more unusual ones (Stroop, 1935).

The version of the Stroop test used in this study was the Golden version (Golden & Freshwater, 1978). The test had 3 different sections of 100 items each and participants had 45 seconds per section to complete as many items as possible. The first section ("Word (W)" or "neutral condition") required participants to read the names of colors printed in black ink. The second section ("Color (C)" or "congruent condition") had consecutive X symbols printed in red, blue, or green and participants had to identify the color of the print. In third section ("Color-Word (CW)" or "incongruent condition") items were names of colors (Red, Blue, and Green), but printed in a different color from the word (Ex: green are printed in red). Participants had to identify the color of the printed word instead than read the word, which rise an automatic verbal response that requires many of the neuropsychological function used to name the colors. The speed of both reactions is enormous, which makes that the answer to naming the words occupy the neuropsychological channels which, in turn, the color naming response needs to be able to be processed (Raposo & Esgalhado, 2012). The "Color-Word" task measures the individual's ability to separate stimuli and, in this way, processed and select information.

The number of correct items for each section were considered. When an incorrect response occurs, participants were asked to correct and continue. The errors are not counted, but produce a smaller score, since it causes the participant to repeat the element (Fernandes, Rodríguez, & Silva, 2012).

Golden version suggests three scores where each consists of the number of correct items in 45 seconds and allow to determine the "stroop interference" by calculating CW-CW' (Fernandes et al., 2012; Raposo & Esgalhado, 2012).

2. Transcription test

The transcription test was done using Typing Master 10 (TypingMaster Pro, TypingMaster, Helsinki, Finland). In every session participants were provided with different texts of similar difficulty. The participants were asked to transcribe as much of the text as possible in five minutes, while making a few mistakes as possible. The participants could only correct the word they were transcription, whereas the typed text could not be modified. Typing Master 10 provides the performance report on the test that includes gross speed (the speed which the text were typed), gross strokes, accuracy (accuracy percentage counts the amount of words that were correct) and errors.

3. Profile of Mood States

The Portuguese adaptation of short version of Profile of Mood States (Viana, Almeida, & Santos, 2012) (Annex 3) is a 42-item self-report measure of emotional and mood states derived from the short version of Raglin and Morgan (1989). Participants indicated the degree to which they experienced each adjective (i.e. impatient, nervous and happy) within the previous week on a Likert 5-point scale (0=Never to 4=A lot).

This version comprises 6 subscales Tension-Anxiety (T), Depression-Melancholy (D), Hostility- Anger (H), Fatigue – Inertia (F), Vigor – Activity (V) and Confusion – Disorientation (C) each composed of 6 items. The remaining 6 items are part of the Training Adjustment Scale, developed by Raglin and collaborators (1989), which allows assistance in the diagnosis of overtraining syndrome (Viana et al., 2012), that were not used in this study.

A total mood disturbance (TMD) score was calculated by summing the subscale scores, subtracting the result from the vigor scale and adding a constant of 100 to avoid a negative result ((T+D+H+F+C-V)+100).

4. Mini-Mental Examination

In this study was used the Portuguese adaptation of Mini-Mental State Examination that was developed by Guerreiro et al. (1994). This is a quick application test (5-10 minutes), with 30 item organized in six cognitive domains: Orientation, Retention, Attention and Calculation, Delayed recall, Language, Repeating and Constructive Ability.

If the participant not responds or responds incorrectly score 0 and if responds correctly score 1. The test allows for a maximum 30-point and the obtained scores are related to the educational level of the respondent: it is considered the existence of cognitive impairment if illiterate patients have a score less than 15, those with 1-11 years of schooling have a score less than 22 and those with 11 or more years of schooling have less than 27.

IV. Procedures

This study was a randomized controlled trial and the participants were casually divided in 2 groups: “Control” – simulated office tasks were equally performed, but in a traditional workstation (without exercise) and “Test” – performed office tasks in an active workstation (using cycle ergometer). Initially, participants had a familiarisation session with the computer tasks and the workstation.

The study was composed by three measurements on different days with 1 trial of Transcription Test and 1 trial of SCWT (with 3 sections). The order of the tests to be performed is selected so as to be different for each time.

Both transcription and Stroop test during approximately 5 minutes each. However, each measurement during 30 minutes to participants achieved minimum recommendations for daily exercise (Koren, Pisot, & Simunic, 2016; WHO, 2010) . For the remaining 25 minutes the participants continued to performed simulated office tasks (mouse and keyboard tasks).

In each session participants answered the short version of the Profile of Mood States - Portuguese adaptation (Viana et al., 2012) and the Portuguese adaptation of Mini-Mental State Examination (Guerreiro et al., 1994).

V. Data analysis

Statistical analyses were conducted using IMB SPSS statistics version 25 and the graphics were constructed with Microsoft Excel 2013. The normality of the data was tested with one-sample Kolmogorov-Smirnov test. Data descriptive statistics were presented in mean ± standard deviation.

The level of significance (p) considered was 0.05. Paired students t-tests were used to compare differences between control and group tests in transcription and Stroop performance for the three moments ($p1$, $p2$ and $p3$). Differences between the performance on typing and Stroop tests in three measurement moments was compared with One-Way ANOVA with repeated measures with Bonferroni correction in which condition (without exercise and using cycle ergometer).

VI. Results and discussion

The results that participants obtained in the SCWT are presented in Table 2.

Table 2- Descriptive statistics for SCWT

Control group (n=10)	**Moment 1**	**Moment 2**	**Moment 3**
Word (W)	80.60 (±10.28)	84.50 (±9.51)	84.10 (±14.90)
Color (C)	67.40 (±8.34)	71.80 (±7.83)	75.80 (±9.11)
Color_Word (CW)	48.30 (±9.97)	56.20 (±6.23)	62.70 (±10.58)
Test group (n=10)			
Word	86.60 (±18.19)	84.50 (±18.59)	81.40 (±18.23)
Color	71.30 (±11.77)	75.20 (±10.76)	78.70 (±11.85)
Color_Word	51.10 (±8.85)	56.60 (±11.02)	58.70 (±18.36)

All values are displayed as mean ± SD.

As can be observed in Table 2, the variable W, which corresponds to the number of correct words spoked by the participants, assumed values between 80.60±10.28 and 84.10±14.90 to the control group. Concerning the test group, the correct number of words ranged between 81.40±18.23 and 86.30±18.19. Regarding this variable results show that the values are very similar in both groups. Statistical analysis showed that the number of correct words are independent of the group ($p1=0.376$; $p2= 0.404$; $p3=0.515$). There was also no significant effect in Word between three measurements moments ($p=1.00$).

The results to C variable showed that there was no significant differences ($p1=1.00$; $p2=0.403$; $p3=0.547$) between groups (no exercise and cycling), for the three moments. However, when compared between moments, as can be seen in the Table 2, the values have been increasing over the time in both groups (control group - 67.40±8.34; 71.80±7.83; 75.80±9.11; test group - 71.30±11.77, 75.20±10.76, 78.70 ±11.85).

This tendency is supported by statistical tests which revealed a significant difference between moments 1 and 2 ($p=0.01$), between moments 2 and 3 ($p=0.00$) and moments 1 and 3 ($p=0.00$). These results may be explained by the fact that participants were more familiar with Stroop tasks in moment 2 than moment 1, and so on (Davidson, Zacks, & Williams, 2003).

In the last section (CW task), the results for the 3 measurements moments for control group were 48.30(±9.97), 56.20(±6.23) and 62.70(±10.58) and to the test group are 51.10(±8.85), 56.60(±11.02) and 58.70(±18.36). Statistical tests revealed that there was no significant differences between control and test groups for the three measurement moments (*p*1= 0.52; *p*2= 0.92; *p*3= 0.56).

CW results are lower than in the other 2 Stroop tasks (W and C) because of the "Stroop effect". This can be explained because the word reaches the processing stage of response first than the information related to color: if the word matches the color, this will make naming easier but, if the word conflicts, the interference must be overcome in order to generate a correct response, which leads to a longer response time in the naming of color (Macleod, 1991). When comparing between moments is possible to observe in Table 2 that CW results are increasing over the time for both groups, which also occurred in the results of the Stroop interference calculation.

The results of Stroop Interference are presented in Figure 6.

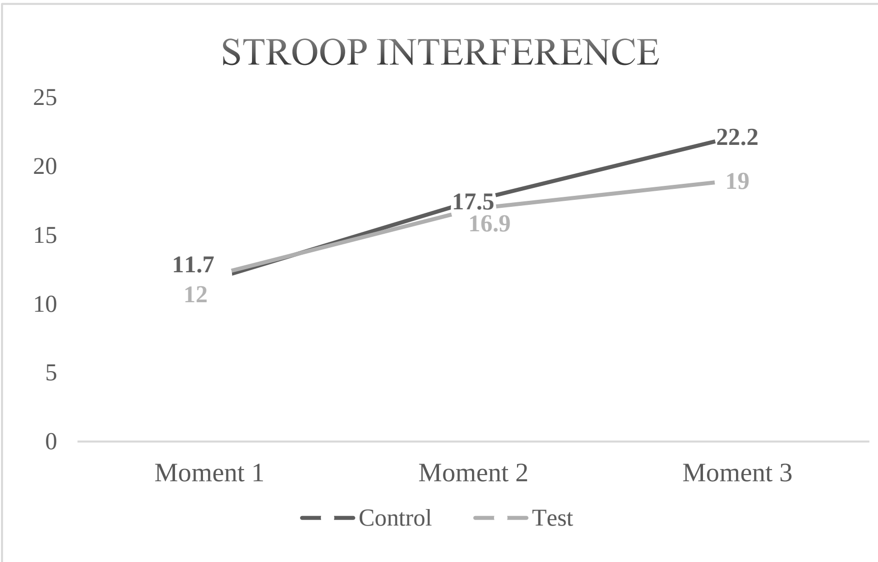


Figure 6- Results for Stroop Interference

Since the calculation of the interference is made based on the results obtained in the Color-Word task, as can be seen in Figure 6, the values for Stroop interference was also increasing over the measurements for sitting and cycling condition. Statistically significant differences were found between moments 1 and 2 (*p*=0.01) and moments 1 and 3 (*p*=0.00). This increasing of values over the time explains an increase in resistance to Stroop interference. These results are significant, since this increase in interference Stroop is a result of better scores in CW task over the time, which revealed an improvement of selective attention and inhibitory control. The participants were able to direct attention to naming the color and supress all other stimuli. However, this could happen because the practicing should strengthen the corresponding connections and thereby reduce interference (Protopapas, Vlahou, Moirou, & Ziaka, 2014).

In general, between groups (sitting and cycling), the SCWT results showed that no was significant differences for the 3 sections of the SCWT. The study conducted by Torbeyns et al. (2016) showed the same pattern. Studies that used the Stroop test are more common when the active workstation has a treadmill and some of that also indicate that exercising has no significant effects in the cognitive function on SCWT (Alderman, Olson, & Mattina, 2014; John et al., 2009; Ohlinger et al., 2009). However, other studies that used SCWT suggests that exercise improved cognitive function, specifically selective attention and response inhibition (Baker et al., 2010; Martinsen et al., 2017). Additionally, there are studies that mentioned a decrement in cognitive performance during exercise. This may be explained by the "transient hypofrontality hypothesis", which suggests that higher cognitive processes supported by the prefrontal cortex (i.e. attention and inhibitory control) are impaired during exercise, which causes a severe strain on the capacity to processing information (Dietrich, 2006).

The Figures 7 and 8 present the results obtained by the participants in transcription test. The Figure 7 shows the speed which participants typed the texts, in Words Per Minute (WPM) and the Figure 8 concern the errors made by the participants.

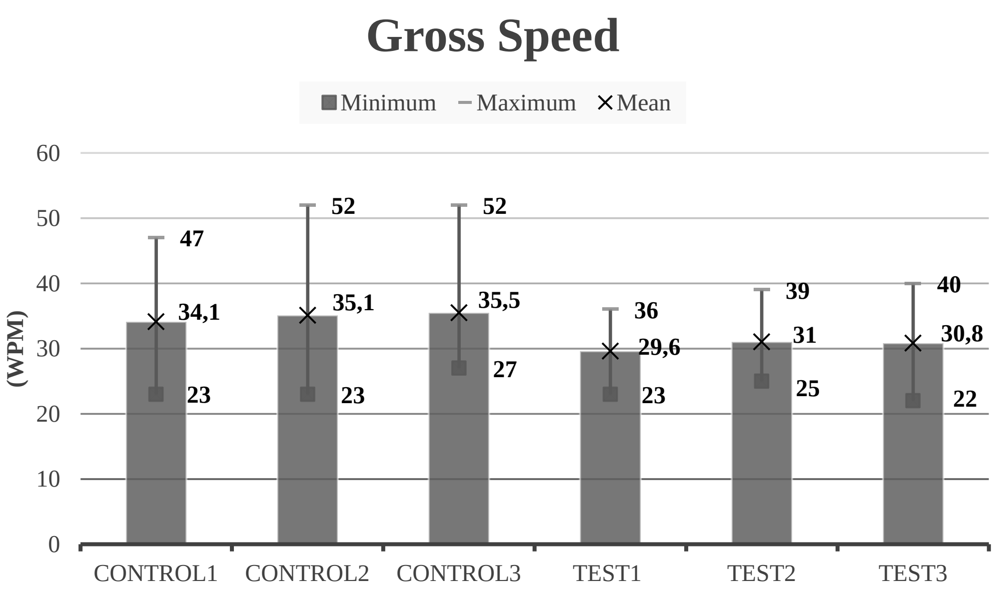


Figure 7- Results for Gross speed

As can be observed in Figure 7, in generally, the control group had better results of gross speed: the control group had WPM mean values between 35.5 and 34.1 and the test group obtained values between 31.0 and 29.6. However, statistical analysis did not revealed significant differences for the 2 groups at the three measurements (*p*1= 0.12; *p*2=0.19; *p*3=0.15). The repeated measures ANOVA equally revealed that no was significant differences between the 3 measurement moments, as can also be seen in Figure 7.

The errors participants made in the transcription test are present in Figure 8.

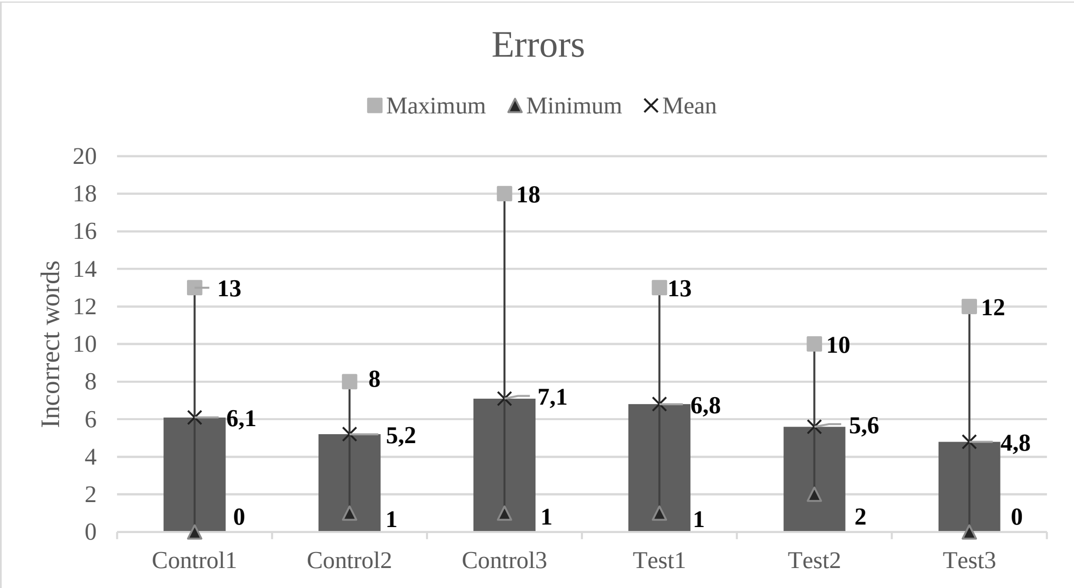


Figure 8- Errors in transcription test

In generally, as can be seen in Figure 8, the control group made a smaller quantity of errors than test group (6.1 and 6.8 in moment 1 and 5.2 and 5.6 in moment 2, respectively), with the exception of the third measurement (7.1 and 4.8). However, there was no statistically significant differences between this 2 groups (*p*1=0.72; *p*2=0.74; *p*3= 0.31), as Koren, Pisot and Simunic (2016) referred in their study.

The means presented in Figure 8 revealed that in the test group the number of incorrect words typed are decreased over the time (6.8, 5.6 and 4.8 errors), which was not found for the control group (6.1, 5.6 and 7.1 errors). Though, statistical analysis did not revealed significant differences between any moments.

Therefore, typing performance (gross speed and errors) did not differed between conditions (sitting/cycling). This results are supported by several studies (Carr et al., 2014; Elmer & Martin, 2014; Torbeyns et al., 2016). Data showed that, after one session, participants became familiar with the combination of cycling and performing a fine-motor skill (Torbeyns et al., 2016). In comparison to treadmill workstation, Carr et al. (2014) reported that a cycling workstation allows the conservation of steady hand-eye coordinator crucial during computer work and requires a lower draw of cognitive resources, which also may be the explanation for not having differences between sitting/cycling. However, some studies showed instead that cycling had significant effect on typing performance, where cycling seemed to increased typing speed (Cho, Freivalds, Rovniak, Sung, & Hatzell, 2014) and decreased errors rate. Straker et al. (2009) noted an opposite trend, concluded that cycling resulted in a decrement in typing performance. In this last study, the participants suggested that the decrement in typing performance could be caused by the cognitive overload associated with dual tasking. This might be an indicator that fine-motor skills would not be the best kind of task to do while pedalling (Cho et al., 2014).

In general, the results of typing performance while using active workstation generated many conclusions. The treadmill workstation is indicated and classified as inefficient solution for typing performance, since many studies revealed a decrease in type speed and an increase in errors (Commissaris et al., 2014; Funk et al., 2012; John et al., 2009; Larson et al., 2015; Thompson & Levine, 2011) which may be due to the higher level of bodily movements involved (Carr et al., 2014; Straker et al., 2009).

In studies with a "sit-stand" workstations most of the results indicated the absence of significant differences in typing performance between the two conditions (sitting and stand) (Ebara et al., 2008; Hedge et al., 2005).

In addition, this type of fine-motor skills (like typing or mouse-pointing) seemed to be affected by different workout intensities, although is impact is smaller in the "light" intensity, which was used in our study (Carr et al., 2014; Cho et al., 2014; Funk et al., 2012; Straker et al., 2009).

The results related to the mood states, which was measured through the application of POMS questionnaire, are present in Figure 9 and 10.

The Figure 9 present the results for each POMS dimensions.

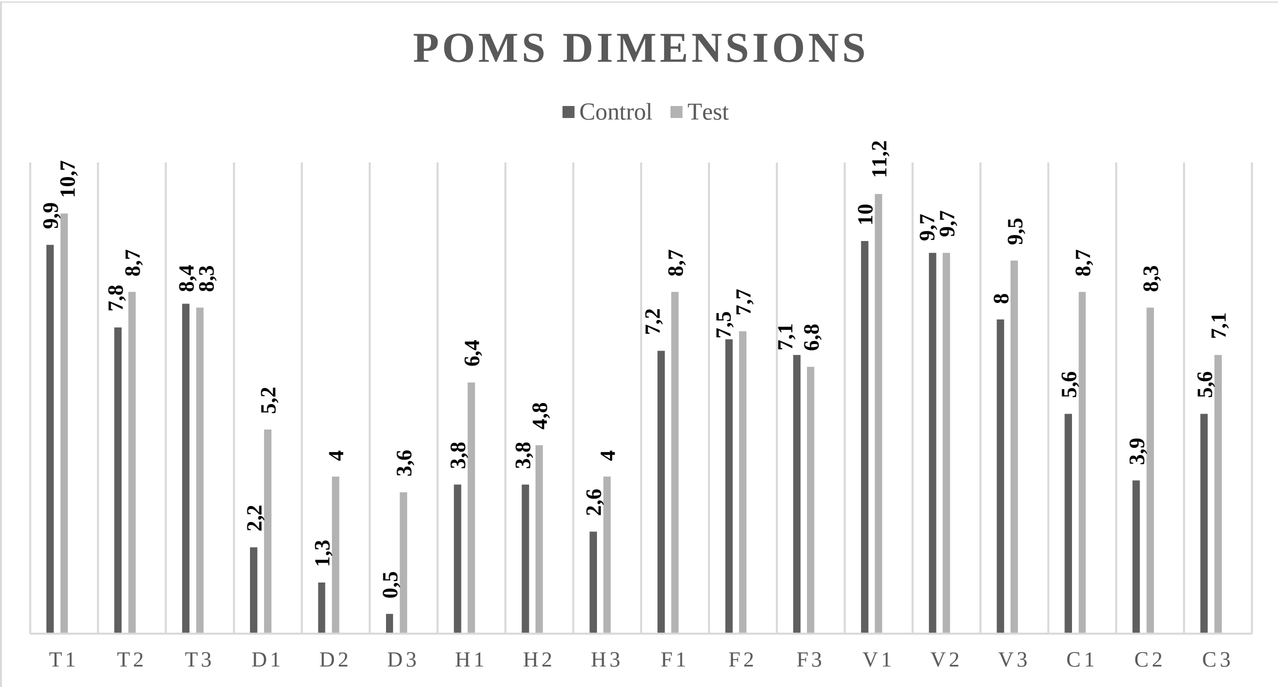


Figure 9- POMS dimensions results

In general, as can be observed in Figure 9, the scores to POMS dimensions are higher in test group: The tension- anxiety (T) dimension obtained values between 7.8 and 9.9 to control group and 8.3 and 10.7 to test group; the depression-melancholy (D) scores are among 0.5 and 2.2 to control group and 3.6 and 5.2 to test group; hostily-anger (H) subscale had values between 2.6 and 3.8 to control group and 4.0 to 6.4 to test group; the fatigue-inertia (F) dimension had values among 7.1 and 7.5 to sitting condition and 6.8 and 8.7 to cycling condition; to the vigor-activity (V) subscale the values varied between 8.0 and 10.0 to control group and 9.5 and 11.2 to test group; confusion-disorientation (C) dimension resulted in values between 3.9 and 5.6 to sitting condition and 7.1 and 8.7 to cycling condition.

However, statistical analysis does not allow to consider these differences significant among groups and measurement moments (all $p>0.05$).

POMS questionnaire allows to calculate a Total Mood Disturbance.

The results for TMD, to control and test groups, are presented in Figure 10.

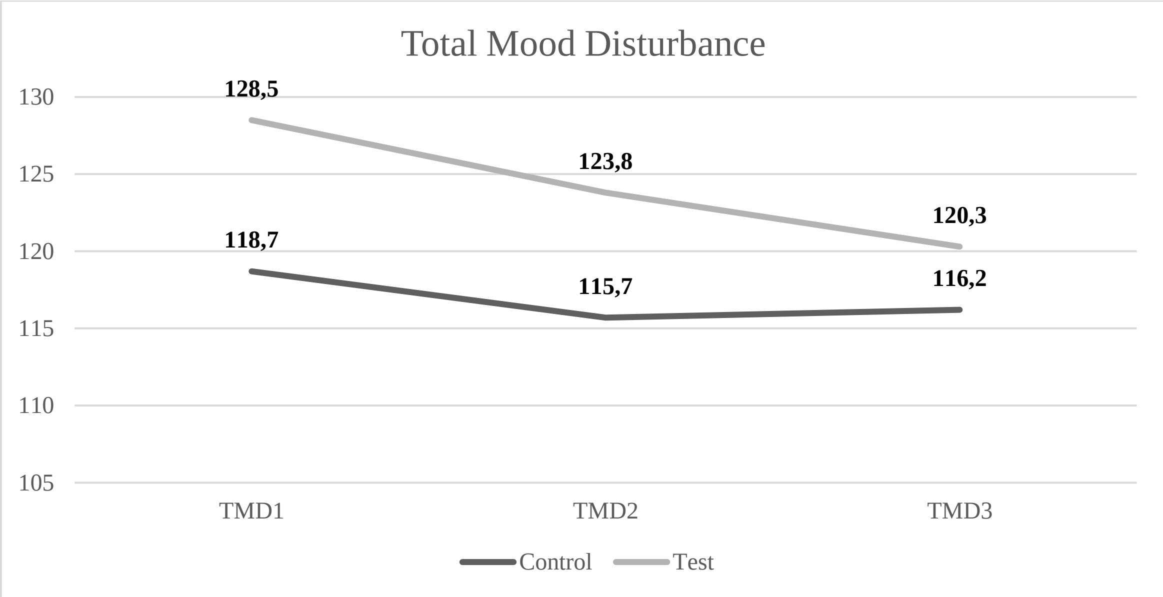


Figure 10- Total Mood Disturbance results

The Figure 10 revealed that in the test group, although having a higher value, TMD was decreasing over the time (128.5, 123.8 and 120.3), in contradiction with control group results (118.7, 115.7 and 116.2). This can be explained by the improvement that exercise can cause in the mood state. Few studies related to use of active workstation included mood state, but Pronk, Katz, Lowry, & Payfer (2012) suggests an improvement of this condition, as the results demonstrated an enhancement for fatigue, vigor, tension, confusion and depression, which resulted in total mood improvement. Other studies have revealed that using active workstations resulted in less reported stress (Edelson & Danoffz, 1989; M. Sliter & Yuan, 2014). However, according ANOVA repeated measures these differences between measurement moments are not statistically significant, neither between moment 1 and 2 (P=0.22), or moment 2 and 3 (p=1.00) or moment 3 and 1 (p=0.16).

VII. Conclusion

Sitting time and sedentary behaviour are some of the largest problems today, with huge repercussions on health. Active workstation seems to be a solution to reduce those questions, since many people spend most of their time in workplace. Office and computer tasks may be assumed the most sedentary jobs.

Some significant positive differences were founded between measurement moments to both groups, which could allow to conclude that practice and familiarization with tasks are essential. This could also reduce the negative impact of active workstations that was founded in some research.

In general, these results support the theory that active workstation provides a good solution to reduce sitting time and sedentary behaviour without comprise the cognitive and work performance.

The POMS questionnaire results allowed to conclude that mood states could be related to performance and, in turn, could be influenced by the practice of light exercise. It is important to develop more research in this field, since the psychological disturbances (such as the mood state) are not as perceptible as physical ones, and, in many cases, they could be the main factor for a decrease in performance.

Several limitations to this study should be noted: the cycle ergometer resistance should have been individualized by participants age, anthropometry and other settings, which did not happen due to technical issues of the equipment and to facilitate comparisons; not all participants had the same rest time between measurements, because of the difficulty in reconciling schedules and availability of the services for measurements; this study was limited to short periods of assessment, it may not have been a representative period of a working day, but as the participants were college students had tight schedules and the study was done in a controlled environment to simulate office work; the number of participants may have limited our aptitude to apply scientific rigor to statistical analyses.

Future research should be developed with a larger sample and investigate individual differences (e.g. gender, anthropometry measures and fitness level) that may influenced the impact of active workstations. It is an asset that future studies should recruited male and female to ensure greater representativeness of the results.

More studies are necessary to explore the cost-benefit of implementing active workstation. If these benefits can be shown to employers, it may be possible to convince them to invest on this workstations. Besides that, it is important developed studies in real office environment and understand the feedback from workers while using active workstation. Future studies should explore the main limitations associated with ergonomic issues in active workstations. It is important to investigate other solutions to stimulate the employee movement and its effects on cognitive function and work performance, such as active breaks with the practice of physical activities that encompass the psychological domain (such as yoga and Pilates).

Organizational strategies that promote physical activity in workplaces, either with the implementation of active workstations or other initiatives, and the training and awareness of workers to these issues are the main steps to changing sedentary behavior.

References

Alderman, B. L., Olson, R. L., & Mattina, D. M. (2014a). Cognitive Function During Low-Intensity Walking: A Test of the Treadmill Workstation. *Journal of Physical Activity and Health*, *11*, 752–758. https://doi.org/10.1123/jpah.2012-0097

Alkhajah, T. A., Reeves, M. M., Eakin, E. G., Winkler, E. A., Owen, N., & Healy, G. N. (2012). Sit–Stand Workstations: A Pilot Intervention to Reduce Office Sitting Time. *American Journal of Preventive Medicine*, *43*(3), 298–303.https://doi.org/10.1016/j.amepre.2012.05.027.

Alvarez, J. A., & Emory, E. (2006). Executive Function and the Frontal Lobes: A Meta-Analytic Review. *Neuropsychology Review*, *16*(1). https://doi.org/10.1007/s11065-006-9002-x

Anderson, P. (2002). Assessment and Development of Executive Function (EF) During Childhood. *Child Neuropsychology*, *8*(2), 71–82. https://doi.org/10.1076/chin.8.2.71.8724

Anderson, V., Jacobs, R., & J., P. (2008). *Executive Functions and the Frontal Lobes: A Lifespan Perspective*.

Audiffren, M., Tomporowski, P. D., & Zagrodnik. (2008). Acute aerobic exercise and information processing : energizing motor processes during a choice reaction time task. *Acta Psychologica*, 129(3), 410-9. https://doi.org/10.1016/j.actpsy.2008.09.006

Baker, L. D., Frank, L. L., Foster-Schubert, K., Green, P. S., Wilkinson, C. W., McTiernan, A., Craft, S. (2010). Effects of Aerobic Exercise on Mild Cognitive Impairment. *Archives of Neurology*, *67*(1), 71–79. https://doi.org/10.1001/archneurol.2009.307

Beedie, C. J., Terry, P. C., & Lane, A. M. (2000). The Profile of Mood States and Athletic Performance: A Meta-analysis. *Journal of Applied Sport Psychology*, *12*(1), 49–68. https://doi.org/10.1080/10413200008404213

Bell, M. A., & Deater-Deckard, K. (2007). Biological Systems and the Development of Self-Regulation: Integrating Behavior, Genetics, and Psychophysiology. *J Dev Behav Pediatr*, *28*, 409–420. https://doi.org/10.1097/DBP.0b013e3181131fc7

Blair, C., & Diamond, A. (2008). Biological processes in prevention and intervention: the promotion of self-regulation as a means of preventing school failure. *Development and Psychopathology*, *20*(3), 899–911. https://doi.org/10.1017/S0954579408000436

Byrne, A., & Byrne, D. G. (1993). The Effect of Exercise on Depression, Anxiety and Other Mood States: A Review. *In Journal of Psychosematic Research Journal of Psychosomatic Research*, *37*(6), 565–574. https://doi.org/10.1016/0022-3999(93)90050-P

Cao, C., Liu, C., Zhu, W., & Ma, J. (2016). Effect of Active Workstation on Energy Expenditure and Job Performance: A Systematic Review and Meta-analysis. Journal of Physical Activity & Health, *13*(5), 562–571. https://doi.org/10.1123/jpah.2014-0565

Carr, L. J., Maeda, H., Luther, B., Rider, P., Tucker, S. J., & Leonhard, C. (2014). Acceptability and effects of a seated active workstation during sedentary work: A proof of concept study. *International Journal of Workplace Health Management*, *7*(1), 2–15. https://doi.org/10.1108/IJWHM-03-2013-0008

Chaddock, L., Erickson, K. I., Prakash, R. S., Vanpatter, M., Voss, M. W., Pontifex, M. B., … Kramer, A. F. (2010). Basal Ganglia Volume Is Associated with Aerobic Fitness in Preadolescent Children. *Dev Neurosci*, *32*, 249–256. https://doi.org/10.1159/000316648

Cho, J., Freivalds, A., Rovniak, L., Sung, K., & Hatzell, J. (2014). Using a Desk-Compatible Recumbent Bike in an Office Workstation. https://doi.org/10.1177/1541931214581347

Clore, G. L., Jr., R. S. W., Dienes, B., Gasper, K., Gohm, C., & Isbell, L. (2001). Affective Felings as Feedback: Some Cognitive Consequences. *Theories of Mood and Cognition: A User's Guidebook*, *27*.

Colcombe, S. J., Erickson, K. I., Scalf, P. E., Kim, J. S., Prakash, R., McAuley, E., … Kramer, A. F. (2006). Aerobic Exercise Training Increases Brain Volume in Aging Humans. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *61*(11), 1166–1170. https://doi.org/10.1093/gerona/61.11.1166

Commissaris, D., Konemann, R., Hiemstra-Van Mastrigt, S., Burford, E.-M., Botter, J., Douwes, M., & Ellegast, R. P. (2014). Effects of a standing and three dynamic workstations on computer task performance and cognitive function tests. *Applied Ergonomics*, *45*(6), 1570–1578. https://doi.org/10.1016/j.apergo.2014.05.003

Coulson, J. C., Mckenna, J., & Field, M. (2008). Exercising at work and self-reported work performance. *International Journal of Workplace Health Management*, *1*(3), 176–197. https://doi.org/10.1108/17538350810926534

Cox, R. H., Guth, J., Siekemeyer, L., Kellems, B., Baker Brehm, S., & Ohlinger, C. M. (2011). Metabolic Cost and Speech Quality While Using an Active Workstation. *Journal of Physical Activity and Health*, *8*, 332–339. https://doi.org/10.1123/jpah.8.3.332

Davidson, D. J., Zacks, R. T., & Williams, C. C. (2003). Stroop interference, practice, and aging. *Neuropsychology, Development, and Cognition. Section B, Aging, Neuropsychology and Cognition*, *10*(2), 85–98. https://doi.org/10.1076/anec.10.2.85.14463

Davis, C. L., Tomporowski, P. D., McDowell, J. E., Austin, B. P., Miller, P. H., Yanasak, N. E., Naglieri, J. A. (2011). Exercise improves executive function and achievement and alters brain activation in overweight children: a randomized, controlled trial. *Health Psychology : Official Journal of the Division of Health Psychology, American Psychological Association*, *30*(1), 91–8. https://doi.org/10.1037/a0021766

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135–68. https://doi.org/10.1146/annurev-psych-113011-143750

Dietrich, A. (2006). Hypothesis Transient hypofrontality as a mechanism for the psychological effects of exercise. *Psychiatry Research*, *145*, 79–83. https://doi.org/10.1016/j.psychres.2005.07.033

Dishman, R. K., Berthoud, H.-R., Booth, F. W., Cotman, C. W., Edgerton, V. R., Fleshner, M. R., … Zigmond, M. J. (2006). Neurobiology of Exercise. *Obesity*, *14*(3), 345–356. https://doi.org/10.1038/oby.2006.46

Donnelly, J. E., & Lambourne, K. (2011). Classroom-based physical activity, cognition, and academic achievement. https://doi.org/10.1016/j.ypmed.2011.01.021

Druss, B., Rosenheck, R., & Sledge, W. (2000). Health and Disability Costs of Depressive Illness in a Major U.S. Corporation. *Am J Psychiatry*, *157*(8), 1274–1278. https://doi.org/10.1176/appi.ajp.157.8.1274

Dunstan, D. W., Wiesner, G., Eakin, E. G., Neuhaus, M., Owen, N., LaMontagne, A. D., Healy, G. N. (2013). Reducing office workers' sitting time: rationale and study design for the Stand Up Victoria cluster randomized trial. *BMC Public Health*, *13*(1), 1057. https://doi.org/10.1186/1471-2458-13-1057

Ebara, T., Kubo, T., Inoue, T., Murasaki, G., Takeyama, H., Sato, T.,Itani, T. (2008). Effects of Adjustable Sit-stand VDT Workstations on Workers' Musculoskeletal Discomfort, Alertness and Performance. *Industrial Health*, *46*, 497–505. https://doi.org/10.2486/indhealth.46.497

Edelson, N., & Danoffz, J. (1989). Walking on an electric treadmill while performing VDT office work. *ACM SIGCHI Bulletin*, *21*(1), 72–77. https://doi.org/10.1145/67880.67890

Elmer, S. J., & Martin, J. C. (2014). A cycling workstation to facilitate physical activity in office settings. *Applied Ergonomics*, *45*, 1240–1246. https://doi.org/10.1016/j.apergo.2014.03.001

Fernandes, S., Rodríguez, J., & Silva, C. (2012). Adaptación del Test de Colores y Palabras de Stroop: Su Importancia en la Detección Precoz de los Déficits en las Funciones Ejecutivas. *Revista Ecuatoriana de Neurología*, *21*(29).

Funk, R. E., Taylor, M. L., Creekmur, C. C., Ohlinger, C. M., Cox, R. H., & Berg, W. P. (2012). Effect of walking speed on typing performance using an active workstation. *Perceptual & Motor Skills: Exercise & Sport*, *115*(1), 1–10. https://doi.org/10.2466/06.23.26.PMS.115.4

Golden, C. J., & Freshwater, S. M. F. (1978). *Stroop Color and Word Test manual* (Stoelting Co). Chicago.

Guerreiro, M. P. S. A., Silva, A. P., Botelho, M. A., Leitão, O., Castro-Caldas, A., & Garcia, C. (1994). Adaptação à população portuguesa da tradução do Mini Mental State Examination (MMSE).

Hall, J., Mansfield, L., Kay, T., & McConnell, A. K. (2015). The effect of a sit-stand workstation intervention on daily sitting, standing and physical activity: protocol for a 12 month workplace randomised control trial. *BMC Public Health*, *15*. https://doi.org/10.1186/s12889-015-1506-y

Hassmén, P., Koivula, N., & Uutela, A. (2000). Physical Exercise and Psychological Well-Being: A Population Study in Finland. *Preventive Medicine, 30,* 17–25. https://doi.org/10.1006/pmed.1999.0597

Hedge, A., Jagdeo, J., Agarwal, A., & Rockey-Harris, K. (2005). Sitting or standing for computer work – Does a negative-tilt keyboard tray make a difference? Proceedings of the Human factors and Ergonomics society 49th Annual Meeting, 808–812.

John, D., Bassett, D., Thompson, D., Fairbrother, J., & Baldwin, D. (2009). Effect of Using a Treadmill Workstation on Performance of Simulated Office Work Tasks. *Journal of Physical Activity and Health*, *6*, 617–624. https://doi.org/10.1123/jpah.6.5.617

Koren, K., Pisot, R., & Simunic, B. (2016). Active workstation allows office workers to work efficiently while sitting and exercising moderately. *Appl Ergon*, 54, 83-9. https://doi.org/10.1016/j.apergo.2015.11.013

Kuoppala, J., Lamminpää, A., & Husman, P. (2008). Work Health Promotion, Job Well-Being, and Sickness Absences—A Systematic Review and Meta-Analysis. *Journal of Occupational and Environmental Medicine*, *50*(11), 1216–1227. https://doi.org/10.1097/JOM.0b013e31818dbf92

Lane, A. M., Whyte, G. P., Terry, P. C., Nevill, A. M., & Lane, A. (2005). Mood, self-set goals and examination performance: The moderating effect of depressed mood. *Personality and Individual Differences*, *39*(1), 143–153. https://doi.org/10.1016/j.paid.2004.12.015

Larson, M. J., LeCheminant, J. D., Hill, K., Carbine, K., Masterson, T., & Christenson, E. (2015). Cognitive and Typing Outcomes Measured Simultaneously with Slow Treadmill Walking or Sitting: Implications for Treadmill Desks. *PLOS ONE*, *10*(4). https://doi.org/10.1371/journal.pone.0121309

Ledwidge, B. (1980). Run for your mind: Aerobic exercise as a means of alleviating anxiety and depression. *Canadian Journal of Behavioural Science/Revue Canadienne Des Sciences Du Comportement*, *12*(2), 126–140. https://doi.org/10.1037/h0081048

Levine, J. A., & Miller, J. M. (2007). The energy expenditure of using a "'walk-and-work'" desk for office workers with obesity. *BR J Sports Med*, *41*, 558–561. http://doi.org/10.1136/bjsm.2006.032755

MacEwen, B. T., MacDonald, D. J., & Burr, J. F. (2015). A systematic review of standing and treadmill desks in the workplace. *PREVENTIVE MEDICINE*, *70*, 50–58. https://doi.org/10.1016/j.ypmed.2014.11.011

Macleod, C. M. (1991). Haifa Century of Research on the Stroop Effect: An Integrative Review. *Psychological Bulletin*, *109*(2), 163–203. http://doi.org/10.1037/0033-2909.109.2.163.

Martinsen, S., Flodin, P., Berrebi, J., Löfgren, M., Bileviciute-Ljungar, I., Mannerkorpi, K.,Kosek, E. (2017). The role of long-term physical exercise on performance and brain activation during the Stroop colour word task in fibromyalgia patients. *Clinical Physiology and Functional Imaging*. https://doi.org/10.1111/cpf.12449

Mcmorris, T., Sproule, J., Turner, A., & Hale, B. J. (2011). Acute, intermediate intensity exercise, and speed and accuracy in working memory tasks: A meta-analytical comparison of effects. *Physiology & Behavior*, *102*, 421–428. https://doi.org/10.1016/j.physbeh.2010.12.007

Miner, A., & Glomb, T. (2010). State mood, task performance, and behavior at work: A within-persons approach. *Organizational Behavior and Human Decision Processes*, *112*(1), 43–57. https://doi.org/10.1016/J.OBHDP.2009.11.009

Naito, M., Nakayama, T., Okamura, T., Miura, K., Yanagita, M., Fujieda, Y., … HIPOP-OHP Research Group. (2008). Effect of a 4-year workplace-based physical activity intervention program on the blood lipid profiles of participating employees: the high-risk and population strategy for occupational health promotion (HIPOP-OHP) study. *Atherosclerosis*, *197*(2), 784–90. https://doi.org/10.1016/j.atherosclerosis.2007.07.026

Netz, Y., & Wu, M.-J. (2005). Physical Activity and Psychological Well-Being in Advanced Age: A Meta-Analysis of Intervention Studies. *Psychology and Aging*, *20*(2), 272–284. https://doi.org/10.1037/0882-7974.20.2.272

Neuhaus, M., Eakin, E. G., Straker, L., Owen, N., Dunstan, D. W., Reid, N., & Healy, G. N. (2014). Reducing occupational sedentary time: a systematic review and meta-analysis of evidence on activity-permissive workstations. *Obesity reviews*, *15*(10), 822–838. https://doi.org/10.1111/obr.12201

Ohlinger, C. M., Cox, R. H., Berg, W. P., & Horn, T. S. (2009). The effect of active workstation use on measures of cognition, attention and motor skill. J Phys Act Health, 8(1):119-25.

Ormel, J., Rijsdijk, F. V., Sullivan, M., Van Sonderen, E., & Kempen, G. I. J. M. (2002). Temporal and Reciprocal Relationship Between IADL/ADL Disability and Depressive Symptoms in Late Life. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *57*(4), P338–P347. https://doi.org/10.1093/geronb/57.4.P338

Owen, N., Healy, G. N., Matthews, C. E., & Dunstan, D. W. (2010). Too much sitting: the population health science of sedentary behavior. *Exercise and Sport Sciences Reviews*, *38*(3), 105–13. https://doi.org/10.1097/JES.0b013e3181e373a2

Parry, S., & Straker, L. (2013). The contribution of office work to sedentary behaviour associated risk. *BMC Public Health*, *13*(296). https://doi.org/10.1186/1471-2458-13-296

Pronk, N. P., Katz, A. S., Lowry, M., & Payfer, J. R. (2012). Reducing Occupational Sitting Time and Improving Worker Health: The Take-a-Stand Project. *Prev Chronic Dis*, *99*. Retrieved from http://dx.doi.org/10.5888.pcd9.110323

Pronk, N. P., Martinson, B., Kessler, R. C., Beck, A. L., Simon, G. E., & Wang, P. (2004). The Association Between Work Performance and Physical Activity , Cardiorespiratory Fitness , and Obesity, *46*, 19–25. https://doi.org/10.1097/01.jom.0000105910.69449.b7

Proper, K., & Van Mechelen, W. (2008). Effectiveness and economic impact of worksite interventions to promote physical activity and healthy diet. *Geneva: World Health Organization*.

Protopapas, A., Vlahou, E. L., Moirou, D., & Ziaka, L. (2014). Word reading practice reduces Stroop interference in children. *ACTPSY*, *148*. https://doi.org/10.1016/j.actpsy.2014.02.006

Raposo, M. S. V., & Esgalhado, M. da G. P. (2012). *Adaptação do Teste Stroop de Cores e Palavras para Adultos Jovens*. Universidade da Beira Interior - Ciências Sociais e Humanas. Retrieved from https://ubibliorum.ubi.pt/bitstream/10400.6/2522/1/Dissertação_Marta_Raposo.pdf

Rebar, A. L., Vandelanotte, C., Van Uffelen, J., Short, C., & Duncan, M. J. (2014). Associations of overall sitting time and sitting time in different contexts with depression, anxiety, and stress symptoms. *Mental Health and Physical Activity*. https://doi.org/10.1016/j.mhpa.2014.02.004

Salo, E. (2017). Brain activity during selective and divided attention. Faculty of Medicine - University of Helsinki, Finland .

Sanchez-Villegas, A., Ara, I., Guillé N-Grima, F., Bes-Rastrollo, M., Varo-Cenarruzabeitia, J., & Martínez-González, M. (2008). Physical Activity, Sedentary Index, and Mental Disorders in the SUN Cohort Study. *Med. Sci. Sports Exerc*, *40*(5), 827–834. https://doi.org/10.1249/MSS.0b013e31816348b9

Seiler, R., Pilcher, J. J., & Baker, V. C. (2016). Task Performance and Meta-Cognitive Outcomes When Using Activity Workstations and Traditional Desks. https://doi.org/10.3389/fpsyg.2016.00957

Sjögren, T., Nissinen, K. J., Järvenpää, S. K., Ojanen, M. T., Vanharanta, H., & Mälkiä, E. A. (2005). Effects of a workplace physical exercise intervention intensity of low back symptoms in office workers : A cluster randomized controlled cross - over design. *Journal of Back and Musculoskeletal Rehabilitation*, *18*, 1–12. https://doi.org/10.3233/BMR-2006-19103

Sliter, M., & Yuan, Z. (2014). Workout at Work: Laboratory Test of Psychological and Performance Outcomes of Active Workstations. *Journal of Occupational Health Psychology*. 20(2), 259-71. https://doi.org/10.1037/a0038175

Smith, M. J., Conway, F. T., & Karsh, B.-T. (1999). Occupational Stress in Human Computer Interaction. *Industrial Health*, *37*, 157–173. https://doi.org/10.2486/indhealth.37.157

Sparling, P. ., Giuffrida, A., Piomelli, D., Rosskopf, L., & Dietrich, A. (2003). Exercise activates the endocannabinoid system. https://doi.org/10.1097/01.wnr.0000097048.56589.47

Steptoe, A., & Bolton, J. (1988). The short-term influence of high and low intensity physical exercise on mood. *Psychology & Health*, *2*(2), 91–106. https://doi.org/10.1080/08870448808400346

Straker, L., Levine, J., & Campbell, A. (2009). The effects of walking and cycling computer workstations on keyboard and mouse performance. *Human Factors*, *51*(6), 831–44. https://doi.org/10.1177/0018720810362079

Stroop, R. J. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *XVIII*(6). http://dx.doi.org/10.1037/h0054651

Thompson, W. G., Foster, R., Eide, D., & Levine, J. A. (2007). Feasibility of a walking workstation to increase daily walking. *Br. J. Sports Med*. https://doi.org/10.1136/bjsm.2007.039479

Thompson, W. G., Koepp, G. A., & Levine, J. A. (2013). Increasing physician activity with treadmill desks. *Work*, *0*, 1–5. https://doi.org/10.3233/WOR-131708

Thompson, W. G., & Levine, J. A. (2011). Productivity of transcriptionists using a treadmill desk. *Work*, *40*(4), 473–477. https://doi.org/10.3233/WOR-2011-1258

Thorp, A. A., Owen, N., Neuhaus, M., & Dunstan, D. W. (2011). Sedentary Behaviors and Subsequent Health Outcomes in Adults. *Journal of Preventive Medicine*, *41*(2), 207–215. https://doi.org/10.1016/j.amepre.2011.05.004

Tomporowski, P. (2003). Effects of acute bouts of exercise on cognition. *Acta Psychologica*, *112*(3), 297–324. https://doi.org/10.1016/S0001-6918(02)00134-8

Torbeyns, T., Bailey, S., de Geus, B., & Meeusen, R. (2015). The use of cycling workstations in public places - an observational study. *Public Health*, *129*(11), 1439–1443. https://doi.org/10.1016/j.puhe.2015.06.010

Torbeyns, T., De Geus, B., Bailey, S., De Pauw, K., Decroix, L., Cutsem, J., & Meeusen, R. (2016). Cycling on a Bike Desk Positively Influences Cognitive Performance. https://doi.org/10.1371/journal.pone.0165510

Treadway, D. C., Ferris, G. R., Hochwarter, W., Perrewé, P., Witt, L. A., & Goodman, J. M. (2005). The Role of Age in the Perceptions of Politics--Job Performance Relationship: A Three-Study Constructive Replication. *Journal of Applied Psychology*, *90*(5), 872–881. https://doi.org/10.1037/0021-9010.90.5.872

Van Den Heuvel, S. G., Boshuizen, H. C., Hildebrandt, V. H., Blatter, B. M., Ariëns, G. A., Bongers, P. M., & Van Den Heuvel, S. G. (2005). Effect of sporting activity on absenteeism in a working population. *Br J Sports Med*, *39*. https://doi.org/10.1136/bjsm.2004.013052

Viana, M. F., Almeida, P., & Santos, R. C. (2012). Adaptação portuguesa da versão reduzida do Perfil de Estados de Humor – POMS. *Análise Psicológica*, *19*(1), 77–92. https://doi.org/10.14417/ap.345

WHO. (2010). Global Recommendations on Physical Activity for Health. *World Health Organization Library Cataloguing-in-Publication Data*.

Wilmot, E. G., Edwardson, C. L., Achana, F. A., Davies, M. J., Gorely, T., Gray, L. J., … Biddle, S. J. H. (2012). Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. *Diabetologia*, (55), 2895–2905. https://doi.org/10.1007/s00125-012-2677-z

Wipfli, B., Rethorst, C., & Landers, D. (2008). The Anxiolytic Effects of Exercise: A Meta-Analysis of Randomized Trials and Dose–Response Analysis. *Journal of Sport & Exercise Psychology*, *30*, 392–410. Analysis-o

World Health Organization. (2012). WHO | Global strategy on occupational health for all: The way to health at work.

Zablah, A. R., Franke, G. R., Brown, T. J., & Bartholomew, D. E. (2012). How and When Does Customer Orientation Influence Frontline Employee Job Outcomes? A Meta-Analytic Evaluation. *Journal of Marketing*, *76*, 1547–7185. https://doi.org/10.1509/jm.10.0231

Zeigler, Z. S., Swan, P. D., Bhammar, D., & Gaesser, G. (2015). Walking Workstation Use Reduces Ambulatory Blood Pressure in Adults With Prehypertension. *Journal of Physical Activity and Health*, *12*, 119–127. https://doi.org/10.1123/jpah.2013-0487

Annex I

Questionário Internacional da Atividade Física (IPAQ) – Versão Curta

Código de Identificação: ___________

Este questionário inclui questões sobre a atividade física que realiza habitualmente para se deslocar de um lado para outro, atividades domésticas (femininas ou masculinas), jardinagem e atividades que efetua no seu tempo livre para entretenimento, exercício ou desporto. As questões referem-se à atividade física que realiza numa semana normal, e não em dias excecionais. Por favor, responda a todas as questões mesmo que não se considere uma pessoa ativa.

Ao responder às seguintes questões considere o seguinte:

- Atividades físicas vigorosas referem-se a atividades que requerem um esforço físico intenso e que fazem ficar com a respiração ofegante.

- **Atividades físicas moderadas** referem-se a atividades que requerem esforço físico moderado e tornam a respiração um pouco mais intensa que o normal.

Ao responder às questões, considere apenas as atividades físicas que realize pelo menos **10 minutos seguidos**.

Q1. Diga-me, nos últimos 7 dias, em quantos dias fez atividades físicas vigorosas, como por exemplo, levantar objetos pesados, cavar, ginástica aeróbica, nadar, jogar futebol, andar de bicicleta a um ritmo rápido?

____ Dias

Q2. Nos dias em que pratica atividades físicas vigorosas, quanto tempo em média dedica normalmente a essas atividades?

____ Horas ____ Minutos

Q3. Diga-me, nos últimos 7 dias, em quantos fez atividades físicas moderadas, como por exemplo, carregar objetos leves, caçar, trabalhos de carpintaria, andar de bicicleta a um ritmo normal ou ténis de pares? Por favor não inclua o "andar".

[ ] Dias

Q4. Nos dias em que pratica atividades físicas moderadas, quanto tempo em média dedica normalmente a essas atividades?

[ ] Horas [ ] Minutos

Q5. Diga-me, nos últimos 7 dias, em quantos dias andou pelo menos 10 minutos seguidos?

[ ] Dias

Q6. Quanto tempo no total, despendeu num desses dias, a andar/ caminhar?

[ ] Horas [ ] Minutos

Q7. Num dia normal, quanto tempo passa sentado?

[ ] Horas [ ] Minutos

Q8. Num dia normal, quanto tempo dedica a ver televisão?

[ ] Horas [ ] Minutos

Muito obrigado pela sua atenção!

Annex II

Mini Mental State Examination (MMSE)

1. Orientação (1 ponto por cada resposta correcta)

Em que ano estamos? _____
Em que mês estamos? _____
Em que dia do mês estamos? _____
Em que dia da semana estamos? _____
Em que estação do ano estamos? _____

Nota:____

Em que país estamos? _____
Em que distrito vive? _____
Em que terra vive? _____
Em que casa estamos? _____
Em que andar estamos? _____

Nota:____

2. Retenção (contar 1 ponto por cada palavra correctamente repetida)

"Vou dizer três palavras; queria que as repetisse, mas só depois de eu as dizer todas; procure ficar a sabê-las de cor".
Pêra _____
Gato _____
Bola _____

Nota:____

3. Atenção e Cálculo (1 ponto por cada resposta correcta. Se der uma errada mas depois continuar a subtrair bem, consideram-se as seguintes como correctas. Parar ao fim de 5 respostas)

"Agora peco-lhe que me diga quantos são 30 menos 3 e depois ao número encontrado volta a tirar 3 e repete assim até eu lhe dizer para parar".
27_ 24_ 21 _ 18_ 15_

Nota:____

4. Evocação (1 ponto por cada resposta correcta.)

"Veja se consegue dizer as três palavras que pedi há pouco para decorar".
Pêra ______
Gato ______
Bola ______

Nota:____

5. Linguagem (1 ponto por cada resposta correcta)

a. "Como se chama isto? Mostrar os objectos:
Relógio ____
Lápis______

Nota:____

b. "Repita a frase que eu vou dizer: O RATO ROEU A ROLHA"

Nota:____

c. "Quando eu lhe der esta folha de papel, pegue nela com a mão direita, dobre-a ao meio e ponha sobre a mesa"; dar a folha segurando com as duas mãos.
Pega com a mão direita____
Dobra ao meio ____
Coloca onde deve____

Nota:____

d. "Leia o que está neste cartão e faça o que lá diz". Mostrar um cartão com a frase bem legível, "FECHE OS OLHOS"; sendo analfabeto lê-se a frase.
Fechou os olhos____

Nota:____

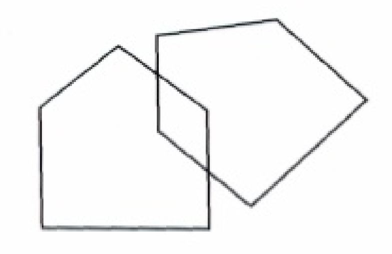
e. "Escreva uma frase inteira aqui". Deve ter sujeito e verbo e fazer sentido; os erros gramaticais não prejudicam a pontuação.

Frase:

Nota:____

6. Habilidade Construtiva (1 ponto pela cópia correcta.)

Deve copiar um desenho. Dois pentágonos parcialmente sobrepostos; cada um deve ficar com 5 lados, dois dos quais intersectados. Não valorizar tremor ou rotação.



Cópia:

Nota:____

TOTAL (Máximo 30 pontos):____

<u>**Considera-se com defeito cognitivo**</u>:
- analfabetos ≤ 15 pontos
- 1 a 11 anos de escolaridade ≤ 22
- com escolaridade superior a 11 anos ≤ 27

Annex III

POMS Adaptação por Viana, Almeida e Santos, 2001

NOME | DATA:

Instruções: São apresentadas abaixo uma série de palavras que descrevem sensações que as pessoas sentem no dia-a-dia. Leia primeiro cada palavra com cuidado. Depois, assinale com uma cruz (X) a quadrícula que melhor corresponda à forma como se tem sentido ao longo dos ÚLTIMOS SETE DIAS INCLUINDO O DIA DE HOJE.

Não escreva nos espaços abaixo. Só para uso interno.

		Nada 0	Um pouco 1	Moderadamente 2	Bastante 3	Muitíssimo 4	T	D	H	V	F	C
1	Tenso											
2	Irritado											
3	Imprestável											
4	Esgotado											
5	Animado											
6	Confuso											
7	Triste											
8	Activo											
9	Mal-humorado											
10	Enérgico											
11	Sem valor											
12	Inquieto											
13	Fatigado											
14	Aborrecido											
15	Desencorajado											
16	Nervoso											
17	Só											
18	Baralhado											
19	Exausto											
20	Ansioso											
21	Deprimido											
22	Sem energia											
23	Miserável											
24	Desnorteado											
25	Furioso											
26	Eficaz											
27	Cheio de vida											
28	Com mau feitio											
29	Tranquilo											
30	Desanimado											
31	Impaciente											
32	Cheio de boa disposição											
33	Inútil											
34	Estourado											
35	Competente											
36	Culpado											
37	Enervado											
38	Infeliz											
39	Alegre											
40	Inseguro											
41	Cansado											
42	Apático											