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Feasibility of a cycling workstation in a simulated office setting: a pilot study

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, e sob coorientação científica do Professor Doutor Rubim Santos, Área Técnico-Científica de Física da Escola Superior de Saúde.

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Resumo

O comportamento sedentário está cada vez mais presente na vida profissional das pessoas e tem efeitos negativos na sua saúde. O exercício físico através de estações de trabalho ativas pode atenuar esses efeitos. O objetivo deste estudo foi investigar a adequabilidade de uma estação de trabalho ativa dotada de ciclo ergómetro, comparando a resposta fisiológica de mulheres saudáveis. Um total de 20 mulheres com idades entre os 18 e 25 anos, com um Índice de Massa Corporal entre os 18.5-25 kg/m^2 e sem historial de lesões músculo-esqueléticas foram selecionadas para o estudo com base no preenchimento do Questionário Internacional de Atividade Física (IPAQ). Os participantes foram divididos em dois grupos: grupo de controlo, que apenas ficava sentado na estação de trabalho, adaptada ergonomicamente, a realizar tarefas de escritório; grupo de teste, com as mesmas condições, mas utilizando uma estação de trabalho com um ciclo ergómetro, onde pedalavam livremente. Foram realizadas 3 medições durante 30 minutos, onde foram observados os seguintes parâmetros fisiológicos: frequência cardíaca (FC), pressão arterial (PA), frequência respiratória (FR), temperatura da pele (TP) e a perceção de esforço (através da aplicação da escala de Borg CR10). Nos resultados da FC, houve um aumento da mesma entre momentos e os resultados do grupo de teste foram 30% maiores que no grupo de controlo. A PA aumentou no grupo de teste em relação ao grupo de controlo. Na FR não houve diferenças entre momentos, contudo existiram diferenças entre grupos, onde o grupo de teste teve resultados 32.9% maiores do que no grupo de controlo. Estes resultados correspondem a respostas fisiológicas típicas de exercício físico leve. A TP não demonstrou diferenças entre momentos e grupos. Os resultados da escala de Borg mostraram que não houve diferenças entre momentos, contudo houve diferenças entre grupos, com o grupo de controlo a classificar o seu esforço como "esforço extremamente ligeiro" e o grupo de teste classificou como "esforço ligeiro". Conclui-se que esta estação de trabalho ativa é adequada para um local de trabalho onde os indivíduos tenham a necessidade de quebrar a monotonia de um trabalho sedentário. Contudo, será necessário explorar estes efeitos em contexto real, juntamente com outras formas de intervenções no local de trabalho.

Palavras-chave: Comportamento sedentário, Estações de trabalho ativas, Ciclo ergómetro, Exercício físico, Resposta fisiológica.

Abstract

Sedentary behavior is increasingly present in people's professional lives and has negative effects on their health. Physical exercise through active workstations may mitigate these effects. The objective of this study was to investigate the feasibility of an active workstation with a cycle ergometer, comparing the physiological response of healthy women. A total of 20 women aged between 18-25 years, with a body mass index between 18.5-25 kg/m^2 and with no history of musculoskeletal disorders were selected for the study based on the completion of the International Physical Activity Questionnaire (IPAQ). Participants were divided into two groups: control group, who only sat at the ergonomically adapted workstation and performed office tasks; test group, with the same conditions but using a workstation with a cycle ergometer, where they pedaled freely. Three measurements were performed for 30 minutes, where the following physiological parameters were observed: heart rate (HR), blood pressure (BP), breathing rate (BR), skin temperature (ST) and perceived exertion from the application of Borg CR10 scale. In the HR results, there was an increase between moments and the results of the test group were 30% higher than in the control group. BP increased in the test group relative to the control group. In BR there were no differences between moments. However, there were differences between groups, where the test group had 32.9% greater results than in the control group. These results correspond to a typical physiological response of light physical exercise. ST did not show differences between moments and groups. The results of the Borg scale showed that there were no differences between moments, but there were differences between groups, where the control group classified their exertion as "very, very light" and the test group classified as "light". This active workstation is viable for a workplace where individuals have the need to break the monotony of a sedentary job. However, these effects need to be explored in real context, along with other forms of workplace interventions.

Keywords: Sedentary behaviors, Active workstation, Cycle ergometer, Physical exercise, Physiological response.

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List of abbreviations and acronyms

BMI – Body mass index

BP – Blood pressure

bpm – Beats per minute/breaths per minute

BR – Breathing rate

cm – Centimeters

HR – Heart rate

HRR – Heart rate reserve

Hz – Hertz

IPAQ – International Physical Activity Questionnaire

kg - Kilograms

kg/m^2 – Kilograms per meter square

m – Meters

MET – Metabolic equivalent

mmHg – Milligrams of mercury

ºC – Celsius degrees

ST – Skin temperature

W – watts

WHO – World Health Organization

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I. Introduction

The technological advances of the last decades have brought many advantages to human life, both at work (with the development of automated machines, which facilitate the accomplishment of occupational activities) and in their daily life (with the arrival of computers, television, smartphones, kitchen robots, etc.). This type of resources has changed people's lifestyle, since they require less physical activity and movement to perform their tasks, leading to the adoption of sedentary behaviors (Owen, Sparling, Healy, Dunstan, & Matthews, 2010).

Sedentary behaviors refers to activities in which the energy expenditure is not substantially above the resting level (Owen et al., 2010; Pate, O'Neill, & Lobelo, 2008). As sedentary behaviors take up more and more time in people's lives, when they are combined with a lack of physical exercise, they lead to a sedentary lifestyle that worsens the health of individuals.

Being seated for long periods of time is very common these days. People with sedentary jobs (e.g. working on the computer) spend about 5 hours to 8 hours sitting during the work day (Healy et al., 2013; McCrady & Levine, 2009). When sedentary jobs are associated with work overload, poorly sized workplaces or hostile work environment, workers are subject to both physical (Blangsted, Søgaard, Hansen, Hannerz, & Sjøgaard, 2008; Gerr et al., 2002) and emotional exhaustion (Almudena, Bes-Rastrollo, Varo-Cenarruzabeitia, & Martnez-Gonzlez, 2008; Kowalska, Bugajska, & Zolnierczyk-Zreda, 2010).

There is an urgent need to decrease workers sedentary behaviors. Several studies have been done to test the possibility of introducing periods of physical activity during working hours, with active workstations. These consists of adapting the workstation with devices, such as treadmill or cycle ergometer, that workers use while working normally at their desks. This will increase the physical activity practiced and improve the health of employees (Bergman, Boraxbekk, Wennberg, Sorlin, & Olsson, 2015).

In general, it has been proven that the introduction of physical activity during working hours is beneficial to the worker and organization, increasing productivity (Schwarz & Hasson, 2011). Most studies focus their goals on the influence of exercise on employee performance. This is the main concern of organizations because workers can focus their attention on physical exercise and decrease their performance at work. However, the physiological response of individuals to physical exercise practiced on active workstations is equally important to study, since exercise can bring many health benefits. Despite its importance, this subject is little discussed in the literature.

The main objective of this pilot study was to investigate the feasibility of the use a cycling workstation in a simulated office setting, comparing the physiological response of healthy women. To achieve this objective, the following specific objectives were defined: (1) Compare the variation in physiological responses, namely in the heart rate, blood pressure, breathing rate and skin temperature between a sitting group (control group) and an exercise group (test group) in different evaluation moments during simulated office tasks; (2) Compare the perceived exertion between a sitting group (control group) and an exercise group (test group) in different evaluation moments during simulated office tasks.

II. Literature review

1. Physical activity and physiological parameters

According to the World Health Organization (WHO, 2017), physical activity is defined as "*any bodily movement produced by skeletal muscles that requires energy expenditure*". When practiced regularly at a moderate-intensity level, physical activity brings significant benefits to individuals' health, such as reducing the risk of cardiovascular disease, diabetes, depression and certain types of cancer. In addition, it also helps to control body weight and other physiologic parameters, helping to maintain normal values (Esparza et al., 2000; Timperio, Cameron-Smith, Burns, Salmon, & Crawford, 2000; Warburton, Nicol, & Bredin, 2006).

In the cardiopulmonary system, heart rate (HR), blood pressure (BP) and breathing rate (BR) are three important factors to consider. The normal HR at rest is between 60 and 100 beats per minute (bpm). If the resting HR values are below the minimum value (<60 bpm – bradycardia) or above the maximum value (>100 bpm – tachycardia), people should be followed by a specialist to monitor the situation (Epstein et al., 2013; Feldman & Goldwasser, 2004). BP is considered normal at rest when systolic BP is <120 millimeters of mercury (mmHg) and diastolic BP is <80 mmHg. With values above these, individuals are diagnosed with hypertension, having the need to be followed by a specialist and are forced to change their lifestyle habits (practicing exercise, changing the diet) (Chobanian et al., 2003; Valverde, Gomes, Tauil, & Rosa, 2006). The normal BR at rest is between 12 and 20 breaths per minutes (bpm). Resting values outside this range should be monitored by a specialist as it may indicate respiratory problems (Lindh, Pooler, Tamparo, & Dahl, 2010; McArdle, Katch, & Katch, 1981).

However, during physical exercise, these parameters increase proportionally with the intensity of exercise. According to the American College of Sports Medicine (2014), through the Karvonen formula, it is possible to calculate the percentage heart rate reserve (%HRR) by the percentage of exercise intensity (Table I). The higher the %HRR, the greater the intensity of the exercise performed. Pereira (2016) mentioned that systolic BP could increase from 120 to 200 mmHg, and diastolic BP from 70 to 160 mmHg while practicing static exertion exercises. According to McArdle, Katch, & Katch (1981), the typical value for BR at moderate exercise is 30 bpm, and at intense exercise is 50 bpm. Body temperature is also a good parameter to control during exercise. The normal values are between 35.5 and 37.7 ºC, and it increases with physical exercise due to the increase of blood flow (Fernandes et al., 2012; Silverthorn, 2017).

Table I. Classification of physical activity intensity. Adapted from American College of Sports Medicine (2014).

Intensity	**HRR (%)**
Very Light	<20
Light	20 to <40
Moderate	40 to <60
Vigorous (hard)	60 to <85
Vigorous (very hard)	85 to <100
Maximal	100

WHO recommends certain levels of physical activity, depending on the age group of the individuals. For adults between 18 and 64 years old (individuals considered "active") it's recommended to practice 150 minutes of moderate-intensity[1] aerobic physical activity per week, or 75 minutes of vigorous-intensity[2] aerobic physical activity per week (WHO, 2010b).

The technological advances of the last 50 years, made people to have less need to use their body, both to perform work tasks and for their domestic activities, becoming more physically inactive (Brownson, Boehmer, & Luke, 2005). Indeed, physical inactivity is considered to

[1] E.g. walking
[2] E.g. jogging

be the fourth risk factor for global mortality, increasing day by day in many countries, with implications for the human health (WHO, 2010b).

The world average level of physically inactive population (≥18 years) is 23.3%. Overall, women (26.8%) are more physically inactive than men (19.8%). In Europe, the level of physical inactivity of the population is slightly higher than the world average level (24.5%), with the difference between the physical inactivity of women and men remaining the same (27.8% and 20.9%, respectively). In Portugal, the level of physical inactivity of the population is considerably higher (37.3%), where 40.8% of women and 33.5% of men are physically inactive (WHO, 2010a).

One of the many consequences of physical inactivity in individuals' health is obesity, which is the excess weight derived from abnormal fat accumulation. WHO (2014b) considers obesity a disease, due to the number of people affected by it worldwide. Obesity can cause and aggravate other health problems such as diabetes and cardiovascular problems (Mancini & Simone, 2000; Wang, Zhang, Zhang, & Zhang, 2011).

One of the measurements that is usually used to define obesity is the Body Mass Index (BMI). BMI measures the weight of an individual based on their body weight and height (Kolimechkov, 2014). It is expressed in kilograms per square meter and is calculated with the following formula:

$$\text{BMI (kg/m}^2\text{)} = \frac{\text{Body weight (kg)}}{\text{Height (m)}^2}$$

Equation I. Body Mass Index (BMI) formula.

The values of BMI are generally grouped into 4 groups: underweight (BMI <18.5 kg/m2), normal weight (18.5 kg/m2 < BMI < 25 kg/m2), overweight (25 kg/m2 < BMI < 30 kg/m2) and obesity (BMI >30 kg/m2) (Kolimechkov, 2014).

Evidence shows that the average BMI of the adult world population is about 24 kg/m^2, with women having slightly higher BMI values than men (24.4 kg/m^2 and 24.2 kg/m^2, respectively) (WHO, 2014a). In European countries, mean BMI is around 26 kg/m^2, but men have, on average, slightly higher BMI values than women (26.5 kg/m^2 and 26.3 kg/m^2, respectively). The Portuguese population has, on average, BMI values equal to that of the European continent (26 kg/m^2), with men having a mean BMI higher than women (26.8 kg/m^2 and 25.4 kg/m^2, respectively) (WHO, 2014a).

These statistical data related to the BMI values are similar to the statistics previously mentioned, on the percentage of physical inactivity of the individuals.

2. Sedentary lifestyle and health implications

In a sedentary lifestyle are involved any activities where the energy expenditure is less than 1.5 units of metabolic equivalent (MET – unit that allows to quantify the intensity of physical activity performed). Sitting, lying down, sleeping and watching TV are examples of sedentary activities (Barnes et al., 2012; Pate et al., 2008).

Jobs that require long sitting periods (e.g. work on office/administrative and call center) are considered to be sedentary jobs (Thorp et al., 2012). In industrialized countries, it's estimated that individuals spend much of their day in the workplace (Church et al., 2011). It's the call center, administrative and white-collar workers who spend a greater number of hours sitting, uninterruptedly, which implies a large decrease in the energy spent in their daily lives (Church et al., 2011; Parry & Straker, 2013; Straker & Mathiassen, 2009; Thorp et al., 2012).

Several studies indicate that the longer people maintain sedentary behaviors, the greater the probability of gaining weight and, consequently, the greater the risk of obesity (Ball, Brown, & Crawford, 2002; Brown, Williams, Ford, Ball, & Dobson, 2005). Chau, van der Ploeg, Merom, Chey, and Bauman (2012), compared sitting time (at work and leisure time), physical activity and obesity of working adults, and concluded that workers with sedentary jobs have a higher risk of obesity, regardless of physical activity or sedentary time outside of work.

Cardiovascular diseases are also related to the lack of activity that the sedentary lifestyle presents (Freak-Poli, Wolfe, & Peeters, 2010; Fung et al., 2000; Healy, Matthews, Dunstan, Winkler, & Owen, 2011). Katzmarzyk, Church, Craig, and Bouchard (2009) studied the relationship between sitting time and cardiovascular disease (among others) and concluded that there was a strong relationship between high sitting times and the risk of developing cardiovascular diseases.

All the factors that lead to sedentary lifestyle can lead to individuals developing type 2 diabetes (insulin-dependent) (Hu et al., 2003; Sargeant, Wareham, & Khaw, 2000), which is the deficient production and segregation of insulin, giving rise to a hyperglycemia (American Diabetes Association, 2006). In a study of Hu et al (2003), where they investigated the relationship between type 2 diabetes and physical exercise, it was possible to conclude that in subjects who had moderate or vigorous physical activity at work and leisure time, the risk of developing type 2 diabetes was much lower than those who had a sedentary lifestyle.

With a higher risk of developing the above-mentioned health complications, it is natural that the risk of mortality is higher for sedentary individuals. In the meta-analysis performed by Chau et al (2013), data from 6 studies relating the sedentary behavior of nearly 600,000 people and the risk of mortality were cross-checked. It was possible to conclude that large periods of sitting time during the day are associated with a high mortality risk and that moderate/vigorous physical activity attenuates the harmful effects of sedentary lifestyle.

3. Active workstations

One way to reduce physical inactivity at work is to apply active workstations. Different types of active workstations were studied, such as: switching between sitting and standing (Sit-to-stand) (Healy et al., 2013; Probst et al., 2013; Schwartz et al., 2016); using a treadmill and/or a cycle ergometer at different speeds/intensities (Commissaris et al., 2014; Koren, Pisot, & Simunic, 2016; Larson et al., 2015; Parry, Straker, Gilson, & Smith, 2013; Tudor-Locke et al., 2014).

The sit-to-stand workstation (example in Figure I) aims to reduce sedentary time (sitting), which has proven to be effective (Probst et al., 2013; Schwartz et al., 2016). In the studies where this active workstation was used, the number of times the participants alternated between positions (sitting and standing) and how much time they were in them were evaluated. The physiological parameters were not significantly evaluated, since the physical activity performed was classified as light.

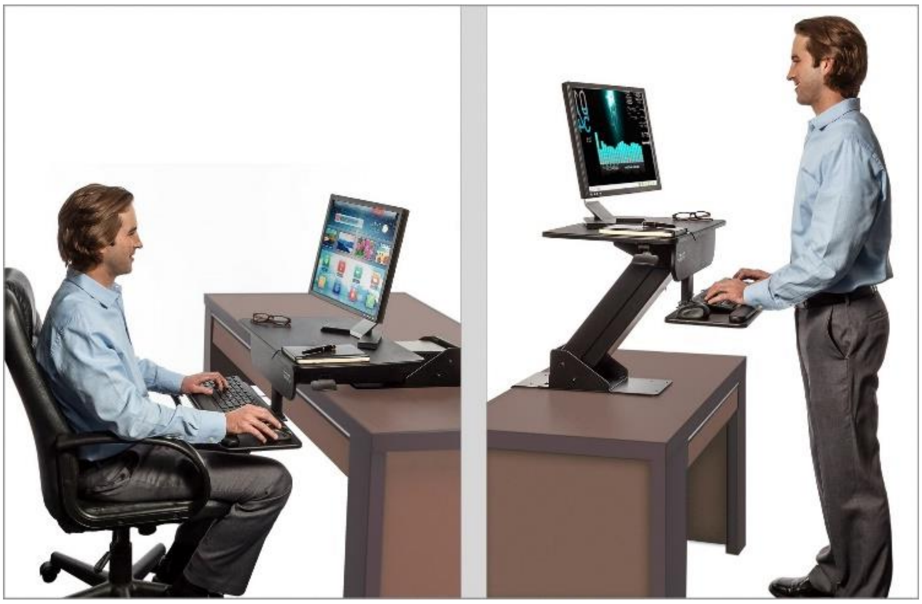

Figure I. Sit-to-stand workstation.

With the use of an active workstation with treadmill (example in Figure II) the goal is that workers, in addition to leaving the sitting position, practice physical exercise while working (usually of moderate-intensity) (Commissaris et al., 2014; Larson et al., 2015; Parry et al., 2013; Straker, Levine, & Campbell, 2009; Tudor-Locke et al., 2014).

Figure II. Active workstation with treadmill.

The studies performed with these active workstations were the ones that presented the most obstacles, especially those performed in real workplaces. The difficulties involved were: the lack of space for the installation of a work table adapted with a treadmill, due to its dimensions, which often implied that the workers had to move the room to use it (Parry et al., 2013; Tudor-Locke et al., 2014); as it was necessary to walk, it required the movement of the whole body, including the arms, which made it very difficult to perform tasks on the computer, and the tests performed on the computer had lower scores in this active workstation (Commissaris et al., 2014; Larson et al., 2015; Straker et al., 2009).

The active workstation with a cycle ergometer (example Figure III) aims to put the workers to exercise while they work, although they also remain in the sitting position. The main factors for the choice of this station were: space, because it occupies less space than, for example, a treadmill; and the possibility evaluate moderate and/or vigorous physical activity, which it is not possible in active workstation with treadmills (Koren et al., 2016; Pilcher & Baker, 2016; Sliter & Yuan, 2015; Straker et al., 2009; Torbeyns, Bailey, de Geus, &

Meeusen, 2015). The negative aspect encountered was the discomfort felt by the workers because of the seat (Koren et al., 2016; Sliter & Yuan, 2015). The results were satisfactory, even from the individuals' perception, since they only needed to move their legs and, at moderate-intensity, physical exercise was not considered uncomfortable (Koren et al., 2016; Pilcher & Baker, 2016; Straker et al., 2009; Torbeyns et al., 2015).

Figure III. Active workstation with cycle ergometer.

III. Materials and methods

1. Participants

The sample selection was made by collecting data through the application of the International Physical Activity Questionnaire (IPAQ). The application of IPAQ has the goal to acquire internationally comparable data on health–related physical activity. It has two versions: long, that has 5 activity domains asked independently ("job-related", "transportation", "housework", "recreation time" and "time spent sitting"); and the short version, that has 4 generic items ("vigorous activity", "moderate activity", "walking time" and "time spent sitting"). Both versions ask about the kinds of physical activities in the last 7 days and, when concluded, it gives information about the categories of physical exercise in which the participants fit: low, moderate or high. (IPAQ, 2002). In this study was used the short version of IPAQ.

The study was conducted in university students of a college in Porto (Portugal). This college is attended by approximately 2,500 students, 186 of whom answered the questionnaire (Figure IV). Inclusion criteria were: female, age between 18-25 years, a BMI between 18.5-25 kg/m^2. The exclusion criteria was that no participant could have a history of musculoskeletal disorders (Koren et al., 2016; Parry et al., 2013).

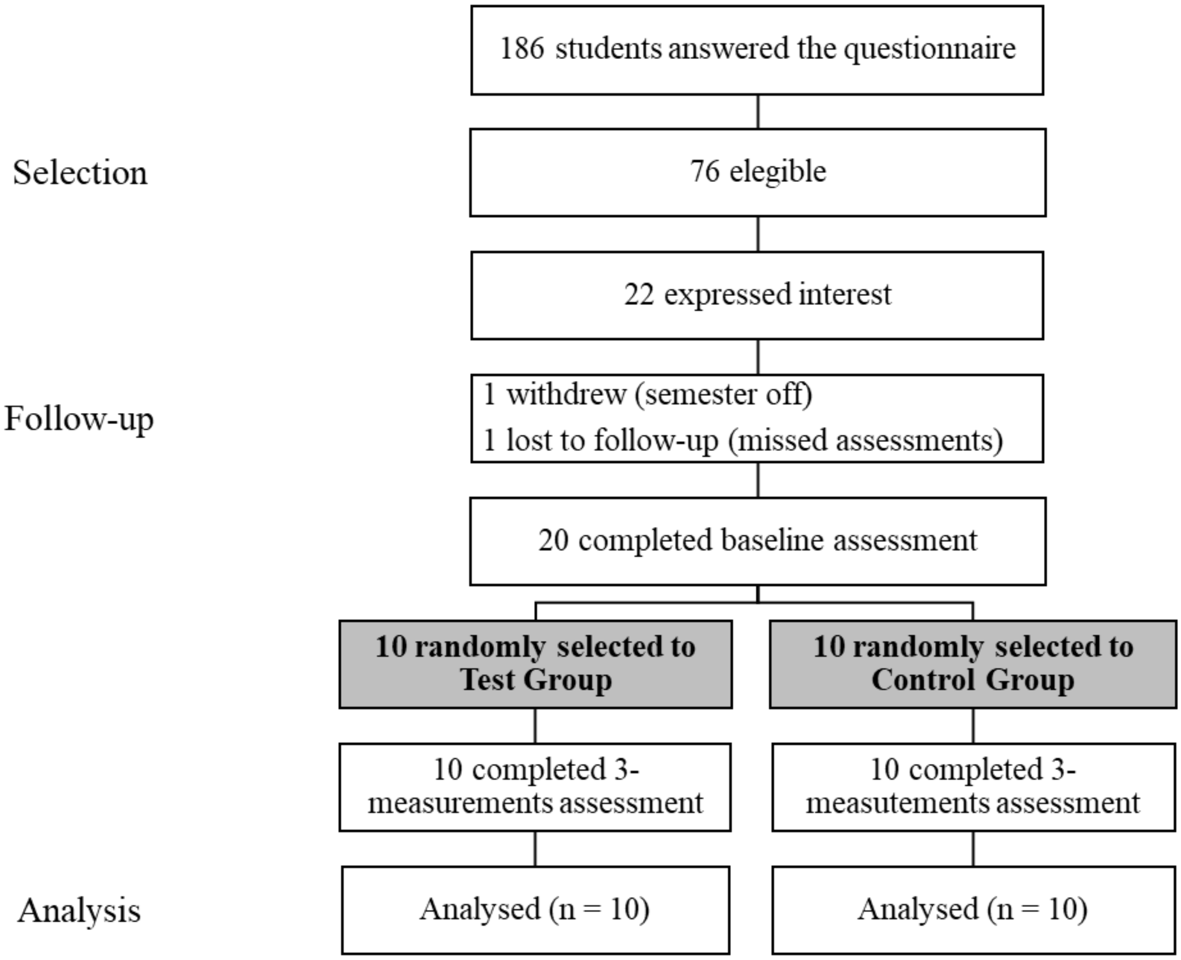

Figure IV. Flow diagram of selection, participation and analyses of participants.

Twenty students fit the inclusion criteria to participate in the study and their demographic, anthropometric information and IPAQ results are presented in Table II. All procedures of the study were fully explained to the participants at the beginning of the protocol and they gave their written consent to participate in the study.

Table II. Participants' demographic and anthropometric information.

Parameter (units)	**Mean (± Std. Deviation)**
N	20
Age (years)	21.15 (± 2.01)
Height (m)	1.64 (± 0.06)
Weight (kg)	57.33 (± 6.85)
BMI (kg/m^2)	21.26 (± 1.82)
Waist circumference (cm)	72.56 (± 6.50)
Arm functional reach (cm)	61.98 (± 4.03)
Eye height sitting (cm)	70.27 (± 2.64)
Popliteal height (cm)	43.60 (± 1.86)
Maximum knee height (cm)	71.38 (± 2.81)
Elbow to wrist length (cm)	31.75 (± 1.87)
Exercise category (number of participants):	
Low	2
Moderate	13
High	5

2. Cycling workstation

A custom-built workstation was built by using a cycle ergometer (Mini Bike O'Fitness FR080D) under a modified desk and chair (Figure V).

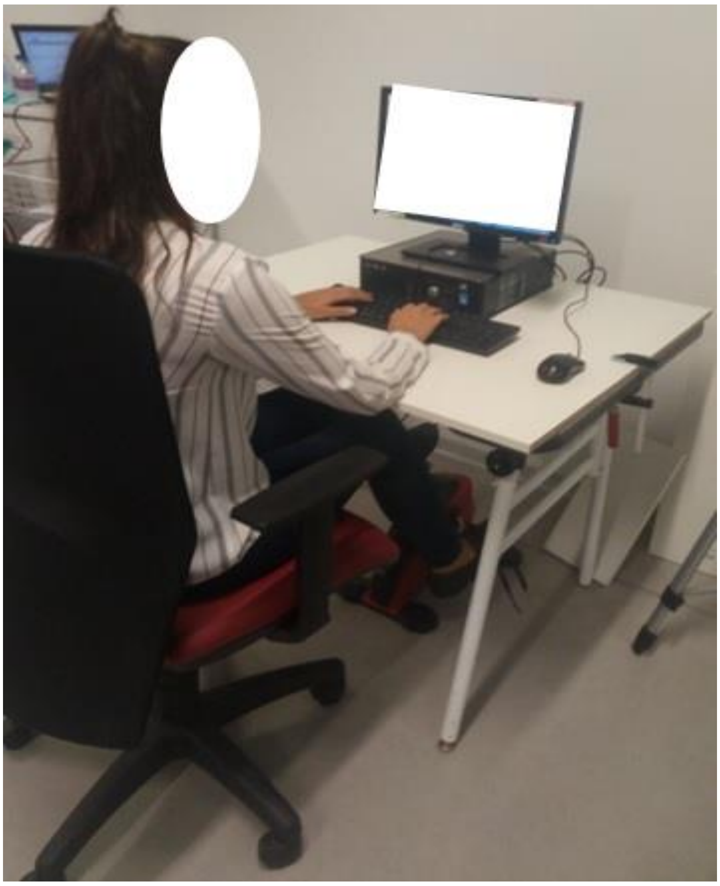

Figure V. Active workstation used in the study.

The table (120x60cm) was adjustable in height, as well as the chair, so that the workstation was considered ergonomic and for the participants to feel comfortable. These measures were not changed throughout the trials. The cycle ergometer workload was always the same for every participant (light). These characteristics were adjusted to each group of participants and were not altered throughout the study (Koren et al., 2016; Straker et al., 2009).

3. Instrumentation and outcomes

Anthropometric measurements of individuals were collected at baseline. The height was measured with a stadiometer (Seca 222). The weight was measured with Seca – Medical Scales and Measuring Systems (Birmingham, UK). These two parameters combined resulted in the Body Mass Index (as it was referred before). Waist circumference was measured with semi-metallic anthropometric tape, placing it between the lower rib margin and the iliac crest (Bergman et al., 2015).

The physiological parameters were evaluated during the participants' performance. Heart rate (HR – 256 Hz), breathing rate (BR – 25.6 Hz) and skin temperature (ST – 0.25 Hz) were measured with a chest belt sensor (EQ02) (Equivital Sensor Electronics Module EQ02, Hidalgo Limited) throughout the task performance. Blood pressure (BP) was measured twice, with a blood pressure monitor (BM35, Beurer), before and after the participant performs the task.

At the end of the task, participants completed a questionnaire – Borg Category-Ratio (CR10) scale – about their perceived exertion (Annex I). Borg CR10 scale combines categories of exercise or physical work perceived with ratio properties (Borg, 1982). The rating score is from 0 (nothing at all) to “maximal” (Borg, 1982; Koren et al., 2016; Pilcher & Baker, 2016; Straker et al., 2009).

4. Experimental protocol

Before starting the tests, a previous test was carried out with 3 individuals to test the feasibility of the equipment and the active workstation. Participants were random divided in 2 groups: “control” – the sitting group, where the tasks were done on a traditional workstation; and “test” – the exercise group, where the tasks were done on an active workstation, using the cycle ergometer, with light workload. Although, the groups were balanced in terms of the category of exercise in which individuals were inserted in order to avoid possible deviations in the results.

The study duration was 3 measurements (exercises were performed once a day). The parameters evaluated were recorded at different times of the study. After collecting the anthropometric measurements and adjust the workstation to the participant, the participants were at rest for some minutes. Then, the EQ02 was installed (Figure VI) and the blood pressure was measured.

Figure VI. Chest belt sensor (EQ02) on the participant.

A brief familiarization (about 3 minutes) with the equipment was performed at the first time. The exercises included tasks in the computer (through cognitive tests that simulated real tasks of office work), for 30 minutes. At the end of the test, blood pressure was measured again, and the participant answered Borg CR10 scale.

5. Data analysis

Data are presented as means with standard deviation. There was no deviation from the normal distribution in the BR and ST variables, however in the other variables there was. Differences in BR and ST variables were tested with One-way ANOVA with repeated measures analysis of variance (within and between groups). For Borg's scale results and HR variables, the differences within groups were tested with Friedman and Wilcoxon test and the differences between groups were tested with Mann-Whitney test. All tests were performed with a significance level of 0.05. The statistic tests were performed with IBM SPSS Statistics 22 and the graphics with Microsoft Office Excel 2016.

IV. Results and discussion

All the participants completed the tests to which they were submitted. Table III shows the mean results for HR, BR and ST, by groups and by moments.

Table III. Evolution on heart rate, breathing rate and skin temperature through the different moments.

	Control group (n = 10)	**Test group (n = 10)**	**Moment 1 (n = 20)**	**Moment 2 (n = 20)**	**Moment 3 (n = 20)**
Heart rate (bpm)	80.7 (± 7.32)	104.9 (± 7.32)	89.5 (± 22.42)	91.1 (± 26.47)	97.6 (± 30.27)
Breathing rate (bpm)	21.4 (± 1.11)	28.4 (± 1.11)	24.3 (± 1.12)	24.9 (± 0.92)	25.4 (± 0.77)
Skin Temperature (ºC)	35.7 (± 0.12)	36.0 (± 0.12)	36.1 (± 0.15)	35.8 (± 0.14)	35.7 (± 0.13)

For the HR, results in Table III demonstrate that there was a significant difference within moments (p = 0.03). The differences were between moment 2 and 3 (p = 0.02), and between moment 1 and 3 (p = 0.02). In comparison to moment 1, HR increased 1.7% in moment 2, and 9% in moment 3. Furthermore, HR increased 7.2% in moment 3, when compared to moment 2. These results can indicate that the participants increased the exercise intensity because their bodies were getting used to the intensity practiced before.

Between the control and the test groups, there was a significant effect of physical exercise on HR in moment 1 (p = 0.03), but there was no significant effect in moment 2 and 3 (p = 0.05). Although, the results of the test group were 30% higher than the control group). The mean HR for control group was within the normal resting heart rate (60 to 100 bpm) (Mason et al., 2007). The mean HR for test group corresponds to a target heart rate for approximately 30 %HRR. This matches to light-intensity exercise, which explains the small increase in heart rate (Garber et al., 2011). There were similar results in the study of Koren, Pisot and Simunic (2016), where the participants from the control group registered a mean HR of 88.6 bpm. The participants from the test group, despite having performed a moderate-intensity exercise, registered a mean HR of 120.8 bpm. Straker, Levine and Campbell (2009) had different results, with the control group (sit) registering a mean HR of 75 bpm, as the test group (slow cycling) registered a mean HR of 79 bpm. However, the tests performed in this last study lasted only about 6 minutes.

The blood pressure results support the explanation for the heart rate results (Table IV). Before the exercise (rest), in comparison with the control group, systolic BP was 3.6% higher and diastolic BP was 3% higher in the test group. After the exercise, in comparison with the control group, systolic BP was 8.5% higher and diastolic BP was 3% higher in the test group. These small variations demonstrate that, although the increase in BP is proportional to the intensity of the exercise (Pereira, 2016), this particular physical exercise was not intense enough to raise blood pressure to significant different levels between rest and exercise.

Table IV. Evolution of blood pressure response for the two groups (control and test group), before and after the exercise.

	Control group (n = 10)		**Test group (n = 10)**	
	Systolic BP	**Diastolic BP**	**Systolic BP**	**Diastolic BP**
BP Before (mmHg)	110 (± 2.20)	67 (± 1.65)	114 (± 2.20)	69 (± 1.65)
BP After (mmHg)	106 (± 2.87)	67 (± 1.60)	115 (± 2.87)	69 (± 1.60)

According to Table III, there was no significant difference in BR between moment 1 and 2 (p = 1.00), moment 2 and 3 (p = 1.00), or moment 1 and 3 (p = 0.81). Although, in comparison with moment 1, BR increased 2.5% in moment 2, and 4.5% in moment 3. In comparison with moment 2, BR increased 2% in moment 3. These results can indicate that the participants increased the exercise intensity because their bodies were getting used to the intensity practiced before.

The increase in BR is proportional to the intensity of the exercise (Pereira, 2016), and as such, there was a significant effect of physical exercise on BR between the control and the test group (p = 0.00). The results of the test group were 32.9% higher than the control group. The mean BR for control group was slightly above normal values for resting BR (12 to 20 bpm) (Lindh et al., 2010). The mean BR for the test group was within the normal values for light-intensity exercise (20 to 30 bpm), which explains the small increase in BR (McArdle et al., 1981).

For the ST, results in Table III demonstrate that there was no significant difference between moment 1 and 2 (p = 0.28), moment 2 and 3 (p = 1.00), or moment 1 and 3 (p = 0.11). Unlike the previous variables, in comparison with moment 1, ST decreased 0.8% in moment 2, and 1.3% in moment 3. In comparison with moment 2, ST also decreased 0.5% in moment 3 (Table III). There was also no significant effect of physical exercise on ST between the control and the test group (p = 0.07). The results of the test group were only 0.8% higher than the control group.

The physiological response of the participants over the time, throughout each measurement, was also evaluated. Figure VII shows the participants HR response during the test.

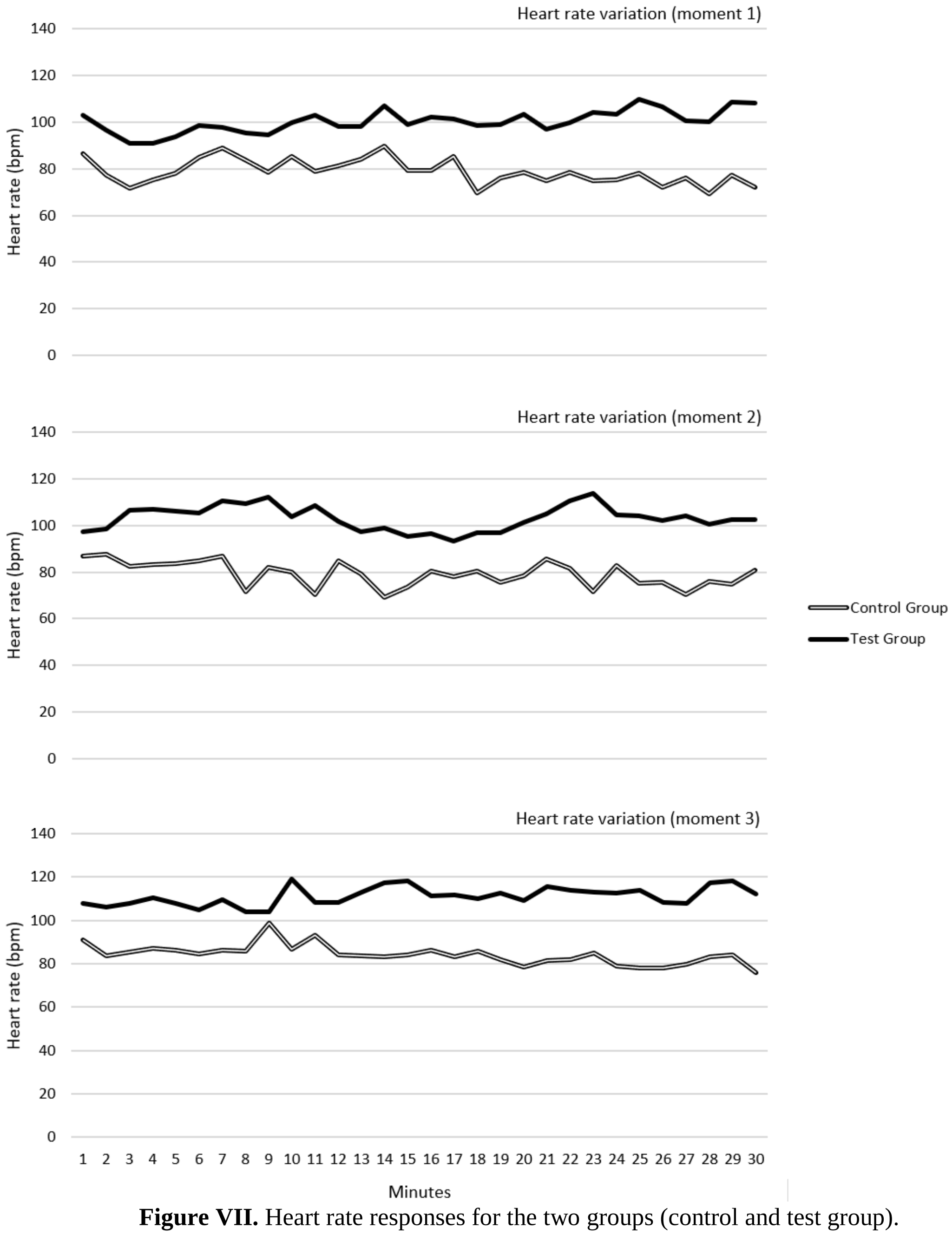

Figure VII. Heart rate responses for the two groups (control and test group).

In general, HR showed fluctuations in the performance of both groups, although they always remained in the respective range. As we can see, at moments 1 and 2, the control group had more fluctuation in their HR values than at moment 3. This can be explained by the fact that individuals increased their level of knowledge of the test over time and were no longer concerned with external factors. The HR values of the test group were more stable over the 3 moments, probably because the participants were focused on pedaling.

It is possible to observe the existence of peaks, in both the control and the test groups. For the control group, this can be explained because participants may have been exposed to some situation that caused some changes, like talking, answering questions, or simply asking how much time was left to complete the task. In the test group, this can be explained by the fact that the participants pedal freely, not having a regular cadence in the exercise, increasing the intensity of pedaling whenever they felt more comfortable.

Figure VIII shows the participants breathing rate response during the tests. As in HR results, BR showed fluctuations in the performance of both groups, although they always remained in the respective range.

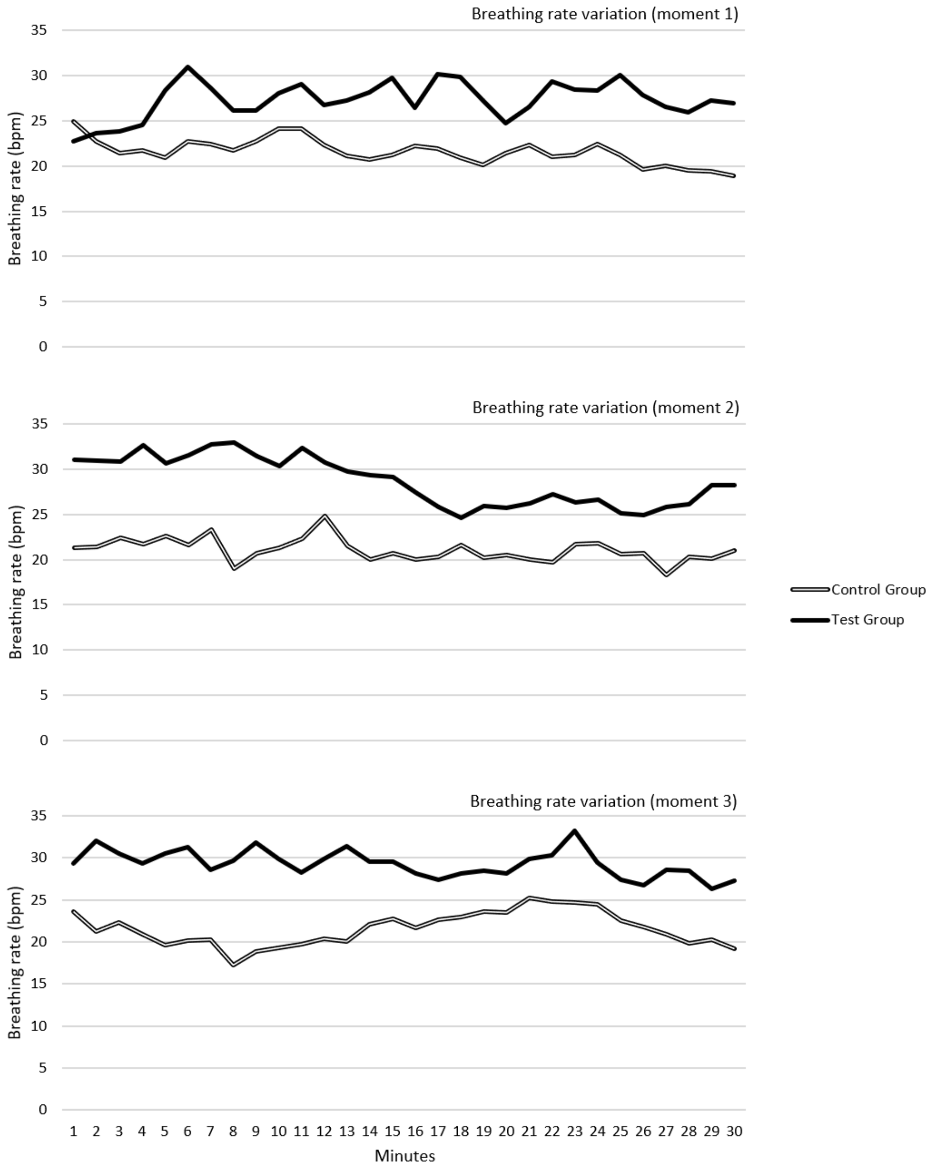

Figure VIII. Breathing rate responses for the two groups (control and test group).

There seems to have been no stability in BR over time and over the 3 moments. This can be explained by the many factors that could interfere with this variable, such as talking. In the case of the test group, the combination of these factors with the exercise cadence may have influenced the breathing fluctuations, since the participants had complete freedom to determine the intensity with which they pedaled.

ST response of participants during the tests are presented in Figure IX. The initial results of ST are slightly below the normal minimum value (35.5 ºC). This can be explained by sweating, the thermoregulatory mechanism of the body to keep body temperature within normal range (Silverthorn, 2017).

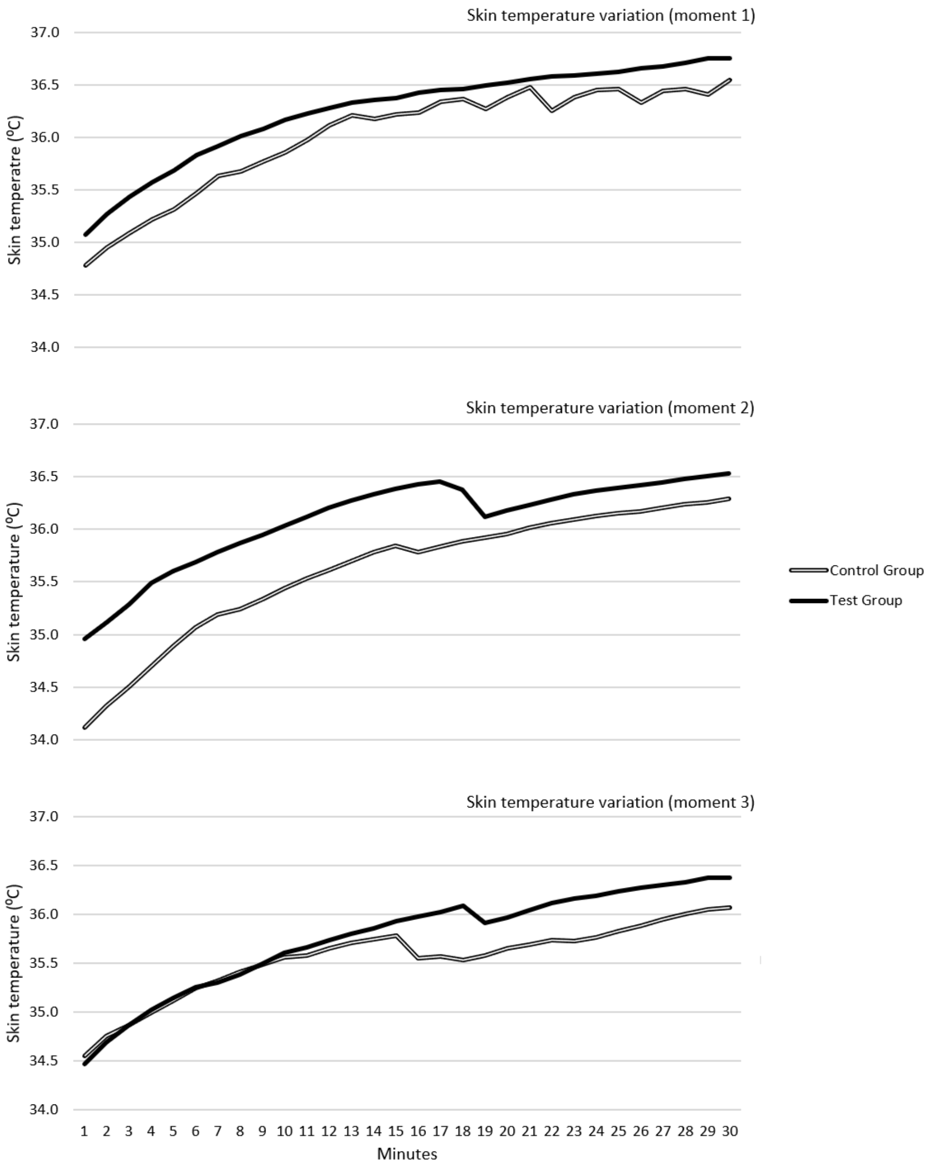

Figure IX. Skin temperature variation for the two groups (control and test group).

The final results, in comparison with the initial results, increased almost 2 ºC for both groups, but never exceeded the normal maximum value (37.7 ºC).

Allied to the fact that, for the test group, the practice of physical exercise increases the body temperature (Fernandes et al., 2012), the days on which the tests were performed were very hot. This can also be an explanation for this variance because all the climatic parameters (air temperature, air humidity and air velocity) alter the thermal environment and can influence body temperature (Höppe, 1999).

The perceived exertion by the participants was also an important result. Table V shows the Borg CR10 scale results, after the exercise. There was no significant difference in Borg CR10 scale results between moments (p = 0.83). Although, there was a significant effect of physical exercise on perceived exertion between the control and the test group, in moment 1 (p = 0.01), moment 2 (p = 0.01) and moment 3 (p = 0.00). Comparing the two groups, the control group had a score corresponding to "Very, very light (just noticeable), and the test group had a score corresponding to "Light". This increase can be associated with an increase in energy expenditure from light-intensity exercise.

Table V. Evolution of Borg CR10 scale results, through the different moments.

	Control group (n = 10)	**Test group (n = 10)**	**Moment 1 (n = 20)**	**Moment 2 (n = 20)**	**Moment 3 (n = 20)**
Borg CR10 scale	0.6 (± 0.25)	1.8 (± 0.25)	1.2 (± 1.08)	1.2 (± 1.01)	1.2 (± 0.98)

These results are similar to the results obtained in the studies conducted by Pilcher and Baker (2016) and Straker, Levine and Campbell (2009). The participants who used the cycle ergometer (in light-intensity or "free wheeling"), rated their perceived exertion in 1.8 and 2.0, respectively, and the ones who used a traditional desk rated their perceived exertion in 0.5 and 0.6, respectively. In the study of Torbeyns, Bailey, de Geus, and Meeusen (2015) , the mean perceived exertion of the exercise (using a cycling desk to charge their devices) by the participants was 2.1. These studies showed that, under normal working conditions, people will choose a lower exercise intensity. If a person uses this type of active workstation freely (with no defined load), the intensity of the exercise falls on light-intensity. For the authors, this intensity of exercise may be sufficient to help prevent the emerge problems related to sedentary behavior if exercise is repeated on daily basis (Torbeyns et al., 2015).

In the study of Koren, Pisot, and Simunic (2016) were used 3 exercise intensities: 0 Watts (W), where the participants performed the test without cycling, 40 W and 80 W, simulating two moderate-exercise intensities. The mean perceived exertion for the 0 W exercise was 0.8, for the 40 W exercise was 2.3, and for the 80 W exercise was 3.3. Among the results of the perceived exertion of the two exercise intensities, the 40 W was the closest to the test group's outcome in this pilot study (1.8 on the Borg scale). The small difference is because, in the study of Koren and her colleagues, the exercise intensity was moderate. With a considerable exercise load, the intensity of 40 W was considered by the participants to be more comfortable in the relation physical exertion-exercise intensity.

In this study, participants did not complain about the effort they had to do to complete the tasks, noting that it was perfectly reasonable to do these exercises at least 30 minutes a day while they worked. These statements can be supported by the fact that 65% of the participants were classified as individuals with moderate physical activity, 25% with high physical activity and only 10% were classified as individuals with low physical activity. They felt comfortable with the intensity of the exercise, admitting that they could increase it over time if they felt that the exercise became easier. However, there were some complaints about the chair (office chair with wheels), because when they pedaled the chair moved backwards, and they had to reposition themselves in the workstation. In a long-term use, this can lead to the adoption of inadequate postures, which are detrimental to the health of the individual, diverting the goal from the active workstation.

This study presents some differences when compared to the Sliter & Yuan (2015) study, where they compared three workstations: sitting, standing, cycling and walking. The individuals preferred the walking workstation (treadmill) because it broke the routine of their work day, once they had to get up, and reduced their perceived stress. Regarding the ergometer cycle, people complained about the discomfort they felt, since they could not coordinate the movement of legs with the tasks that had to do on the computer that involved using the mouse. However, the study of Straker, Levine and Campbell (2009) showed some similarities with this pilot study. The participants used the same active workstations listed in the previously mentioned study, but preferred the cycling workstation because they could do light-intensity exercise without leaving their workstation. They suggested that would be more comfortable if they could choose their own intensity (“free wheeling”), and complained about the discomfort they felt on their hips and glutes. In the same study, some participants suggested that the ideal was the ability to use all the workstations (cycling, standing and walking) for short periods of time whenever they wanted to break up the monotony of their work day.

In fact, these participatory workplace interventions have shown broader and more significant results in the organizations. Healy et al. (2013) conducted a study where the participants were submitted to organizational, environmental and individual changes to improve their physical state. The message was "Stand Up" for at least 30 min, "Sit less" using the sit-stand workstation, and "Move more" that encouraged them to move around the office. In the study of Parry, Straker, Gilson, & Smith (2013) they divided the participants into 3 groups: Group A used the active workstation (treadmill and/or cycling) and participants were given incentives to promote their physical activity (through motivational e-mails and other exercise guidelines); group B used a pedometer with a set number of minimum daily steps, and were encouraged to walk around the office and use the stairs; and group C only performed exercises in the office chair and were encouraged to take more breaks. In both studies, all participants significantly reduced their sedentary time, increased the number of breaks and increased daily physical activity. This indicates that these interventions may be the most effective in changing workers' sedentary behaviors.

V. Conclusion

This study allowed to verify the physiological effect that the physical exercise, practiced through the cycle ergometer workstation, had on the participants. These results showed that the even the light-intensity exercise had impact on the physiological response, and the exertion that the participants have experienced, while significant, was not high enough to become uncomfortable. This means that this active workstation would be viable for being integrated into a workplace. It is possible to establish that the active workstations are a fundamental piece in the future of the organizations and in the quality of life of the workers.

However, it is important to note that this study also had several limitations. The small number of participants was notorious because, once they were university students, it was very difficult to reconcile their schedules with the availabilities that we had to carry out the tests. Because of this, it was only possible to do 3 measurements per participant. The design of the active workstation may also have influenced the results because the chair moved, and may have changed the cadence of the exercise, since the participant had to slow down to reposition himself. External factors such as noise and conversations may also have influenced some outcomes, especially heart rate and breathing rate. However, the aim of this pilot study was to simulate normal working conditions.

In the future, it is necessary to increase the number and diversity of participants in terms of gender, age and BMI, so that the results are closer to reality. It is also important to improve the active workstation at the comfort level and apply this test in a real working context to see the different physiological responses. Allied to this, it is necessary to evaluate the same parameters in participatory workplace interventions to describe the real health benefits of this more complete model in workers.

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Attachments

Annex I – Borg CR10 scale used on the test.

Escala CR10 de Borg

Score	Expressão verbal	Assinale com um (X)
0	Não existe esforço	
0.3		
0.5	Esforço extremamente ligeiro (quase impercetível)	
0.7		
1	Esforço muito ligeiro	
1.5		
2	Esforço ligeiro	
2.5		
3	Esforço moderado	
4		
5	Esforço intenso	
6		
7	Esforço muito intenso	
8		
9		
10	Esforço extremamente intenso (máximo)	
11		
•	Esforço "extremo"	