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Mestrado em Exercício e Bem-Estar

The impact of sit-stand desk interventions on eating behaviors

Dissertação apresentada a provas públicas para a obtenção do Grau de Mestre em Exercício e Bem-Estar, presidida pelo Prof. Doutor António Palmeira, Arguente Prof. Doutora Mónica Sousa e orientado pelo Prof. Doutor Pedro B. Júdice.

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"VERSÃO FINAL"

Dissertação defendida em provas públicas na Universidade Lusófona, Centro Universitário de Lisboa no dia 21/11/2024, perante o júri, nomeado pelo Despacho de Nomeação Nº 1043/2024, de 12 de novembro de 2024, com a seguinte composição:
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Lisboa
2024

Epigrafe

Nunca é tarde para lutar pelos seus sonhos, desde que a sua determinação seja maior que qualquer obstáculo.

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Estou absolutamente orgulhoso por ter sido perseverante e demonstrado resiliência, e estou emocionado por ter concluído mais uma grande etapa da minha vida! Tenho a certeza de que, se o consegui, foi graças a todo o incrível apoio, ajuda e encorajamento constante de tantas pessoas, bem como às pequenas palavras e momentos que me trouxeram de volta ao equilíbrio e me puseram de pé para continuar sempre que estive em baixo.

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Resumo geral

Introdução: Esta dissertação foi realizada tendo por base dois objetivos principais. O objetivo inicial foi a realização de uma revisão sistemática da literatura (RSL) com a intenção de examinar a potencial influência da utilização de uma secretária ajustável em altura e que permite trabalhar em pé (SSD) nos comportamentos alimentares. O segundo objetivo desta dissertação foi realizar um estudo original com base nos dados obtidos numa intervenção randomizada e controlada (RCT), com o objetivo de comparar os indivíduos que utilizaram SSD e os que permaneceram no grupo de controlo (secretária tradicional), e observar diferenças nos hábitos alimentares no que diz respeito à adesão à dieta mediterrânica.

Método: Na RSL foram identificados 2209 estudos, dos quais 1778 foram excluídos, resultando em cinco artigos selecionados para análise de texto completo. No final, quatro estudos foram incluídos na RSL. Uma pesquisa abrangente de várias bases de dados foi realizada para identificar todos os RCTs publicados em inglês entre 2014 e 2023, que envolveram 119 participantes e implicaram a SSD e comportamentos alimentares.

O RCT original incluiu 38 trabalhadores de escritório da Universidade Lusófona e decorreu no ambiente de trabalho dos participantes e teve a duração de seis meses. Os participantes foram aleatoriamente alocados para um de dois grupos (i.e., intervenção ou controlo). Foi efetuada uma avaliação nutricional dos hábitos/comportamentos alimentares utilizando um questionário de 11 itens para avaliar a adesão à dieta mediterrânica no início e no final dos 6 meses.

Resultados: A RSL sugere que as SSD podem ter o potencial de reduzir o apetite e a ingestão energética. No artigo original foram encontradas diferenças entre os grupos, após 6 meses de utilização da SSD, favorecendo o grupo de intervenção com uma maior adesão à dieta mediterrânica (+3,37 pontuação) (p=0,013) e consumo de peixe (+0,79 porções/semana) (p=0,022) e vegetais (+1,0 porções/semana) (p=0,002).

Conclusões: Parece que as SSD podem ter o potencial de afetar positivamente as sensações de apetite e a ingestão energética. Os resultados do estudo original vão no sentido dos da RSL e indicam que a acessibilidade às SSD pode possivelmente promover seleções alimentares mais saudáveis e melhorar a adesão a uma dieta de estilo mediterrânico. No entanto, dada a falta de estudos sobre este tema, são necessários mais estudos para confirmar estes resultados.

Palavras-chave: escritório; trabalho; secretária ajustável; dieta; padrões alimentares.

General abstract

Introduction: This dissertation was undertaken with two main goals. The initial aim was to conduct a systematic literature review (SLR) with the intention of examining the potential impact of sit-stand desk (SSD) utilization on eating behaviors. The second goal of this dissertation was to conduct an original study based on the data obtained from a clustered randomized controlled trial (RCT), with the aim of comparing the individuals who used SSD with those who remained in the control group (i.e., traditional desk), and observing any differences in eating behaviors about adherence to the Mediterranean diet.

Method: A total of 2209 studies were identified, 1778 of which were excluded, resulting in five articles that were selected for full-text analysis. Four studies were ultimately included in the SLR. A comprehensive search of multiple databases was conducted to identify all RCT published in English between 2014 and 2023 that involved 119 participants and were related to SSD and eating behaviors.

The original RCT included 38 office workers from Lusófona University. The study was conducted in the participants' work environment and lasted six months. Participants were randomly assigned to one of two groups (i.e., intervention using SSD or control using traditional desks). A nutritional assessment of eating behaviors was conducted using an 11-item questionnaire to assess adherence to the Mediterranean diet at the beginning and end of the six-month study period.

Results: SSD may have the potential to reduce appetite and energy intake. From the original study, differences were found between groups after 6 months of using the SSD, favoring the intervention group with greater adherence to the Mediterranean diet (+3.37 points) ($p=0.013$) and consumption of fish (+0.79 portions/week) ($p=0.022$), and vegetables (+1.0 portions/week) ($p=0.002$).

Conclusions: It appears that SSD may have the potential to positively impact appetite sensations and energy intake. The findings from the original study indicate that the accessibility to SSD can possibly foster healthier dietary choices and enhance the adherence to a Mediterranean-style diet, which correlates with a multitude of health advantages. However, given the lack of studies on this topic, more studies are needed to confirm these findings.

Keywords: office; workplace; sit-stand desk; diet; eating behaviors.

Abbreviation list

EE – Energy Expenditure

ESC – European Society of Cardiology

NCD – Non-Communicable Diseases

PA – Physical Activity

PI – Physical Inactivity

SB – Sedentary Behavior

SLR – Systematic Literature Review

SSD – Sit Stand Desks

RCT – Randomized controlled trial

WHO – World Health Organization

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CHAPTER I

GENERAL INTRODUCTION

The concept of standing desk dates back to the 18th century, when Thomas Jefferson used a standing desk to work on the Declaration of Independence Contributions of Thomas Jefferson to American medicine (Cohn, 1979). Also, the famous Portuguese writer, Eça de Queirós, used to write their books while standing. However, standing desks haven't gained widespread attention and popularity in the developing world until recent research elucidated about the health risks of sedentary behavior (SB). Due to their potential health benefits and ergonomic design, sit-stand desks (SSD), also known as standing desks or height-adjustable desks, have become increasingly popular in recent years.

These desks allow users to easily switch between sitting and standing, while working. This encourages movement and reduces the negative effects of prolonged sitting (Pronk et al., 2012; Healy et al., 2016). SSD may be classified into several categories, the first of which is manual height-adjustable desk. These desks require manual adjustment using a crank or lever, whereas electric height-adjustable desks feature a motorized mechanism that enables the user to adjust the height of the desk with greater ease. Desk converters represent a third category of standing desks. These devices are placed on top of a normal desk and can be raised or lowered to facilitate the transition to a standing work environment. The main goal of SSD is to facilitate movement and mitigate the adverse health consequences associated with prolonged periods of SB.

The few negative points that have been reported include possible discomfort or fatigue when moving to a standing position for long periods of time, the cost may be a barrier for some individuals or organizations, not all SSD are adjustable enough to accommodate different heights and preferences. The ergonomic benefits of SSD extend beyond the reduction of SB and the promotion of movement. They can also facilitate the adoption of more optimal postures, mitigate the risk of musculoskeletal problems, boost productivity, enhance general well-being, and potentially influence dietary habits and weight management (Starrett & Cordoza, 2016; Sharma et al., 2019).

Nutritional or eating behaviors in the workplace are of significant consequence to the health and well-being of workers (Hyży et al., 2023). Prolonged periods of sitting and frequent snacking can have a considerable impact on the health and productivity of workers (Rosiek et al., 2015; Anderson et al., 2009). The Mediterranean Diet has been demonstrated to have a

profound beneficial impact on health, encouraging the consumption of a variety of fresh, whole, and nutritionally dense foods, such as fruit, vegetables, olive oil, fish, and nuts. It places particular emphasis on the moderation of red meat, processed foods, and refined sugars as part of a comprehensive and well-balanced lifestyle (Trichopoulou, 2021; Biggi et al., 2024). The promotion of optimal nutritional habits within the workplace is a fundamental aspect for ensuring the health and well-being of employees, as individuals spend a large portion of their lives in the work setting. Various strategies can be implemented by workplaces to facilitate the selection of healthy food choices amongst employees, including the provision of healthy alternatives, the promotion of nutrition awareness, the encouragement of shared healthy meals, and the establishment of a supportive environment (Hyży et al., 2023; Bälter et al., 2024).

It is known that physical activity (PA) can somehow interact with the eating choices of people, but the associations between SB and eating behaviors is less explored, with some indications of a deleterious association (Júdice et al., 2024). Moreover, evidence on the impact that interventions designed to reduce SB while at work, such as the SSD-based interventions and its impact on eating behaviors is not explored. Thus, the aim of the present thesis, is first to gather the most recent evidence (i.e., RCTs) on the impact that SSD can have on eating and eating behaviors with a systematic review. Secondly, we used data from a clustered RCT to assess the impact of introducing SSD in the office for 6 months, on eating behaviors of sedentary workers, based on the adherence to the Mediterranean diet (i.e., questionnaire).

REFERENCES

Anderson, L. M., Quinn, T. A., Glanz, K., Ramirez, G., Kahwati, L. C., Johnson, D. B., Buchanan, L. R., Archer, W. R., Chattopadhyay, S., Kalra, G. P., & Katz, D. L. (2009). The Effectiveness of Worksite Nutrition and Physical Activity Interventions for Controlling Employee Overweight and Obesity. *American Journal of Preventive Medicine*, *37*(4), 340–357. https://doi.org/10.1016/j.amepre.2009.07.003

Bälter, K., King, A. C., Fritz, J., Tillander, A., & Halling Ullberg, O. (2024). Sustainable Lifestyle Among Office Workers (the SOFIA Study): Protocol for a Cluster Randomized Controlled Trial. *JMIR Research Protocols*, *13*, e57777. https://doi.org/10.2196/57777

Biggi, C., Biasini, B., Ogrinc, N., Strojnik, L., Endrizzi, I., Menghi, L., Khémiri, I., Mankai, A., Slama, F. B., Jamoussi, H., Riviou, K., Elfazazi, K., Rehman, N., Scazzina, F., & Menozzi, D. (2024). Drivers and Barriers Influencing Adherence to the Mediterranean Diet: A Comparative Study across Five Countries. *Nutrients*, *16*(15), 2405. https://doi.org/10.3390/nu16152405

Cohn, L. H. (1979). Contributions of Thomas Jefferson to American medicine. *The American Journal of Surgery*, *138*(2), 286–292. https://doi.org/10.1016/0002-9610(79)90388-X

Healy, G. N., Eakin, E. G., Owen, N., Lamontagne, A. D., Moodie, M., Winkler, E. A. H., Fjeldsoe, B. S., Wiesner, G., Willenberg, L., & Dunstan, D. W. (2016). A Cluster Randomized Controlled Trial to Reduce Office Workers' Sitting Time: Effect on Activity Outcomes. *Medicine & Science in Sports & Exercise*, *48*(9), 1787–1797. https://doi.org/10.1249/MSS.0000000000000972

Hyży, A., Jaworski, M., Cieślak, I., Gotlib-Małkowska, J., & Panczyk, M. (2023). Improving Eating Habits at the Office: An Umbrella Review of Nutritional Interventions. *Nutrients*, *15*(24), 5072. https://doi.org/10.3390/nu15245072

Júdice, P. B., Carraça, E. V., Santos, I., Palmeira, A. L., Jerónimo, F., & Silva, M. N. (2024). Different sedentary behavior domains present distinct associations with eating-related indicators. *BMC Public Health*, *24*(1), 275. https://doi.org/10.1186/s12889-024-17760-2

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, 2011. *Preventing Chronic Disease*, *9*, 110323. https://doi.org/10.5888/pcd9.110323

Trichopoulou, A. (2021). Mediterranean diet as intangible heritage of humanity: 10 years on.

Nutrition, Metabolism and Cardiovascular Diseases, *31*(7), 1943–1948. https://doi.org/10.1016/j.numecd.2021.04.011

Rosiek, A., Maciejewska, N., Leksowski, K., Rosiek-Kryszewska, A., & Leksowski, Ł. (2015). Effect of Television on Obesity and Excess of Weight and Consequences of Health. *International Journal of Environmental Research and Public Health*, *12*(8), 9408–9426. https://doi.org/10.3390/ijerph120809408

Sharma, P. P., Mehta, R. K., Pickens, A., Han, G., & Benden, M. (2019). Sit-Stand Desk Software Can Now Monitor and Prompt Office Workers to Change Health Behaviors. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *61*(5), 816–824. https://doi.org/10.1177/0018720818807043

Starrett, K., & Cordoza, G. (2016). *Deskbound: Standing Up to a Sitting World*. Victory Belt Publishing. https://books.google.pt/books?id=ROZXEAAAQBAJ

CHAPTER II

The impact of sit-stand desk interventions on eating behaviors: a Systematic Review of Randomized Controlled Trials

ABSTRACT

Introduction: Excessive sedentary behavior (SB) has been identified as an independent risk factor for numerous adverse health outcomes, including non-communicable diseases (NCDs), which are responsible for a significant number of deaths worldwide. Sit-stand desks (SSD) represent a strategy to reduce SB and may interfere with diet. This systematic review aims to analyze the effect of SSD-based interventions on eating behaviors.

Methods: A comprehensive search for peer-reviewed articles published until February 2024 was conducted in several databases (e.g., PubMed, ScienceDirect, Google Scholar, B-On, and EBSCO) to identify all randomized controlled trials (RCT) published in English language related to SSD and eating behaviors.

Results: In total, 2,209 potentially relevant studies were identified, with 1,778 excluded at the preliminary stage based on their titles and abstracts. This resulted in five articles being selected for full-text analysis, and four studies were ultimately included. The studies were conducted between 2014 and 2023 and involved 119 participants. The use of SSD was found to significantly influence sitting time, with those in the intervention group spending less time sitting and more time standing, than the seated control group. Overall, two studies showed no differences between groups for the eating-related outcomes and two investigations showed favorable impact of SSD usage on eating outcomes, with less energy intake and an improvement in appetite sensations, resulting in a lower hunger sensation and enhanced control over prospective food consumption.

Conclusions: It appears that SSD may have the potential to positively impact appetite sensations and energy intake. However, more RCT studies are needed to confirm these indications, especially with larger samples, extended periods of observation, and a more ecological approach.

Registration: PROSPERO (CRD42024503964).

Keywords: Adjustable height workstations; sit-stand workstation; adjustable desk; diet; eating behaviors; dietary patterns.

INTRODUCTION

Evidence shows that sedentary behavior (SB), especially when accumulated in a prolonged and uninterrupted manner, can be an independent risk factor for numerous adverse health outcomes, and the impact of a sedentary lifestyle is a global concern. SB is defined as any waking behavior that involves an energy expenditure (EE) below 1.5 metabolic equivalents (METs) while sitting, reclining, or lying down. Nowadays, people spend significant time in SB activities (e.g., computer-related work, car travel, and screen viewing) (Boudet et al., 2019). Office workers, for instance, may engage in SB for about 77% of their workday (Beretta et al., 2023), and in general, individuals spend between 5 and 10 or more hours a day sitting, which is associated with a higher all-cause mortality rate (Rillamas-Sun et al., 2018). Moreover, approximately 31% of the world's population aged 15 and above do not attain the recommended PA levels (Park et al., 2020). Six or more hours of daily television viewing is linked to an increased risk of death (Hamer et al., 2017; Imran et al., 2018). A recent study by Zhao et al. (2020) found that overall sitting time significantly increases the risk of cardiovascular disease, cancer, and mortality in a dose-dependent manner. However, the current evidence does not provide guidelines for daily SB (King et al., 2019).

Height-adjustable sit-stand desks (SSD) are an excellent strategy for reducing SB, especially in the workplace (Shrestha et al., 2016). Additionally, strategies such as taking a walk when a worker has a coffee break, doing some squats, upper body stretches, shoulder movements every 45-60 minutes, or getting up and moving during television commercial breaks can be other strategies to help reduce SB (Kravitz and Vella, 2016).

Non-communicable diseases (NCDs) are responsible for 15 million deaths annually among individuals aged 30 to 70. These deaths can be prevented by reducing four primary risk factors: tobacco consumption, alcohol consumption, unhealthy diet, and physical inactivity (PI) (Hellevik et al., 2023). According to Snetselaar et al. (2021), a healthy diet must include plant-based foods, fresh fruits, and vegetables, antioxidants, soya, nuts, sources of omega-3 fatty acids, and should be low in saturated and trans fats, animal proteins, and added/refined sugars and salt consumption (Pistollato et al., 2018).

A healthy diet also involves consuming macronutrients, namely carbohydrates, proteins, and fats, in appropriate proportions to meet energy and physiological requirements, without excessive intake (Cena & Calder, 2020).

Individuals interact with the environment in various microenvironments, such as schools and workplaces. These microenvironments are influenced by macro factors such as health systems,

governments, and the food industry, that impact the individuals' dietary choices and indirectly obesity (Kremers et al., 2006).

Introducing SSD in the work setting represents a contextual change in one of the environments where people spend most of their time. To the authors' best knowledge, no systematic review has gathered and analyzed any existing links between changes in SB (i.e., sitting time) and eating behaviors. Therefore, the present systematic review analyzed the effects of SSD interventions (i.e., SB reduction) in the eating behaviors.

METHODS

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021), and it is registered on PROSPERO (CRD42024503964).

Search strategy

A comprehensive search for peer-reviewed articles published until February 10th, 2024, was performed in various databases (i.e., PubMed, ScienceDirect, Google Scholar, B-On, and EBSCO). Additionally, manual searches were performed on PubMed and Google Scholar and included articles references were crosschecked. The search strategy followed PICOS and included five sets of keywords and their respective derivatives, synonyms, and combinations: P: All ages and healthy population which involved interventions with SSD; I: Assessment of changes in SB or sitting time; C: Group that will not use the sit-stand desk (control); O: Assessment of changes in eating behaviors/habits S: RCTs, randomized, cluster or crossover controlled trials.

Eligible articles were retrieved and divided among the two authors (MF & PGFR) for full-text examination. All doubts were discussed with a third author (PBJ) and resolved by consensus.

Eligibility criteria

Included studies were randomized controlled trials (RCT), published in English until February 10th, 2024, involving the use of SSD, including both objective and subjective measures of SB, including any measure of nutrition/diet or eating behaviors in healthy people from all ages.

Studies not involving SSD and not assessing nutrition/diet or eating behaviors were excluded, as well as studies including diet or nutritional-based interventions.

Data extraction and coding

Two authors performed the data extraction. The extracted data included study details (authors, year, country), intervention design, sample characteristics, duration, intervention, outcomes of interest and assessment tools, and main findings. Any divergences or doubts were solved through discussion and consensus with the third author.

Quality assessment

The Effective Public Health Practice Project (EPHPP) tool assessed the studies' risk of bias (Thomas et al., 2004). This tool was used based on several authors' recommendations, showing appropriate content and construct validity. It appraises the methodological quality of the studies according to eight domains: study design, blinding, selection bias, withdrawals/dropouts, confounders, data collection, data analysis, and reporting. Each domain was classified as strong, moderate, or weak based on specific criteria, and their combined score provides an overall quality rating of the evidence (i.e., weak if two or more domains are classified as weak; moderate if one domain is classified as weak, and strong if all the domains are classified as moderate or strong). Two authors critically appraised all the articles selected, and any disagreements were solved through consensus or discussion with a third author (PBJ).

Data synthesis

A narrative analysis of the evidence was performed on the effects of SSD on eating behaviors. The information synthesis was presented in table form. The information was organized by characterizing and quantifying SB (through specific devices), and dietary outcomes (through questionnaires or weighing the food provided).

RESULTS

Literature search

A total of 2209 records were added to CADIMA after all database and manual searches were concluded. After duplicates removal, 1778 were excluded by title and abstract, leaving 5

articles remained for full-text screening. Four articles were included in this review. The PRISMA flowchart (Page et al., 2021) is presented in Figure 1.

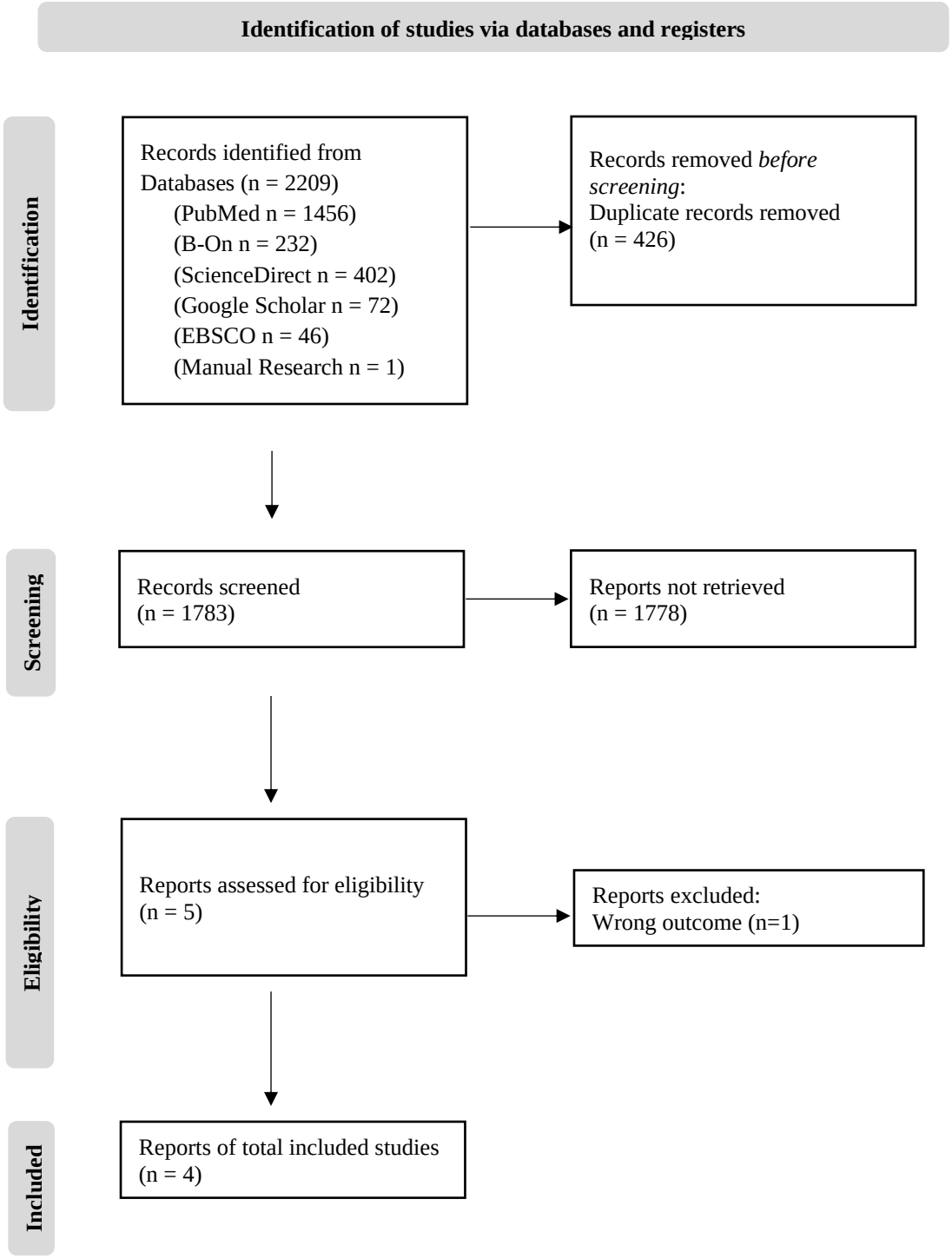

Figure 1 - This study flow diagram follows the preferred reporting items of systematic reviews and meta-analyses.

Studies´ characteristics

The included studies are from 2014 to 2023, all randomized controlled trials or crossover trials comparing one (n=1) or two intervention groups (n=3) with a control group.
Sample. Data from 119 individuals was collected, the sample sizes varied from 15 to 39, with ages ranging from 23 to 40 years old.

The interventions´ duration varied from one 75-minute session (Josaphat et al., 2020), three 45-minute sessions (Metz et al., 2023), 4 weeks (Dutta et al., 2014), and 2 months (Daneshmandi et al., 2021).

SSD were used in all four studies but of different types, such as desk attachments (Dutta et al., 2014; Daneshmandi et al., 2021) and full SSD units (Josaphat et al., 2020; Metz et al., 2023; Dutta et al., 2014).

Self-reported energy and nutrient intake were measured through 24-hour dietary recall (Dutta et al., 2014), nutritionist questionnaire (Daneshmandi et al., 2021), food preference questionnaire (Metz et al., 2023) and Ecological momentary assessment (EMA) questionnaire (Dutta et al., 2014). The satiety quotients were measured through 100-mm visual analog scales and energy intake (Josaphat et al., 2020) and 150-millimeter visual analog scales (Metz et al., 2023).

SB and EE were measured through wearables (Fitbit, accelerometers, ActivPAL, and heart rate monitors) (Metz et al., 2023; Dutta et al., 2014; Daneshmandi et al., 2021), and indirect calorimetry (Metz et al., 2023).

Quality assessment

Of the four included studies, two were classified as having an overall moderate quality (Josaphat et al., 2020; Dutta et al., 2014), and the other two as weak (Metz et al., 2023; Daneshmandi et al., 2021).

All participants were volunteers selected from companies (office workers) or universities (students). The blinding of the interventions did not exist or was not fully followed. For the data collection tools, the authors did not discuss them but often provided adequate information to find the sources. Dropout reasons were not discriminated in most interventions except in Dutta´s study. Detailed information on the quality assessment can be found in Table 1.

Table 1- Quality appraisal of selected studies using Effective Public Health Practice Project.

Study	Design	Blinding	Selection Bias	Dropouts	Confounders	Data Collection	Data Analysis	Report	Global Rating
(Dutta et al., 2014)	Strong	Weak	Moderate	Strong	Moderate	N/A	Strong	Strong	Moderate
(Josaphat et al., 2020)	Strong	Moderate	Moderate	Weak	Strong	N/A	Strong	Strong	Moderate
(Daneshmandi et al., 2021)	Strong	Weak	Moderate	Weak	Moderate	N/A	Strong	Strong	Weak
(Metz et al., 2023)	Strong	Weak	Moderate	Weak	Moderate	N/A	Strong	Strong	Weak

Abbreviations: N/A, not applicable

Table 2 - Included studies' details.

Authors	Study Design	Sample	Duration	Intervention	Outcomes	Results
Dutta et al., (2014), USA	Crossover RCT	N=28 (40.4yrs) 19 Female 9 Male Intervention = 16 Control = 12	10 weeks Intervention: 4 weeks Washout: 2 weeks Control: 4 weeks	Normal office days Intervention: Sit-Stand desks Workfit-S, Workfit-A, Workfit-D. Control: Usual work desks	During intervention Sedentary behavior: Accelerometer Energy and relaxation levels: EMA Energy and nutrient intake: 24-hour dietary recall	Sitting time: intervention ↓ vs control Standing time: intervention ↑ vs control Kcal consumed: intervention ↓ vs control Macronutrients intake: intervention ↓ vs control
Josaphat et al., (2020), Canada	RCT	N=37 16 Female 21 Male Intervention = 19 (25.1 yrs) Control = 18 (23.5 yrs)	One day	Laboratory experimental station with 75´ cognitive task. Intervention: Sit-Stand desks Standing Desk (Anthro Etobicoke, ON, Canada) Control: Usual work desks	Baseline and post-intervention Standardized cognitive task adapted from the Corsi block-tapping task 100-mm visual analog scales Satiety quotients (SQs) Appetite Sensations and Energy Intake	Total energy intake: intervention = control Macronutrients intake: intervention = control Satiety quotients: intervention = control Hunger sensation and prospective food consumption: intervention ↓ vs control
Continue on next page						

Table 2 - Included studies details (continued)

Danesh mandi et al., (2021), Iran	RCT	N=39 23 Female 16 Male Intervention TR1 = 12 (36yrs) TR2 = 12 (33yrs) Control = 15 (32 yrs)	2 months	Normal office days Intervention: Sit-Stand desks TR1 (30´sitting and 30´standing) TR2 (45´sitting and 15´standing) Control: Usual work desks	Baseline and during intervention Energy and nutrient intake: NUT4 software 24-hour dietary recall Energy expenditure: Fitbit	Energy expenditure: intervention ↑ vs control Energy and macronutrient intake: intervention = control
Metz et al., (2023), France	Crossover RCT	N=15 (23.4yrs) 15 Male Intervention/Control =15	Three days	Laboratory experimental station with 45´ cognitive task in three different days separated by 7 days Intervention: Standing position and Walking position - Desk (Activ'UP, Collonges sous Salève, France) Control: Usual work desks	Baseline and post-intervention Indirect calorimetry HR monitor ActiGraph wGT3X-BT accelerometer ActivPAL3 inclinometer Dietary analysis software Restraint, disinhibition, and susceptibility to hunger Ad libitum meals and energy intake Subjective appetite sensations Food preference and reward.	Energy expenditure: Walking Desk ↑ vs Standing Desk/Sitting Desk Energy expenditure: StD = SitD METs: Walking Desk ↑ vs SitD/StD Absolute energy intake/ Kcal consumed/ Macronutrients intake: Walking Desk = StD/SitD Appetite sensations: Walking Desk = StD/SitD

Abbreviations: EMA, Ecological momentary assessment; TR, time regime; StD, standing desk; SitD, sitting desk; Metabolic Equivalent Task (METs), in comparison with control group; N, number of persons. Workfit-S®, desk set-up stand-up attachment; Workfit-A®, setup that attaches to the back of one's existing desk; Workfit-D®, a whole desk that is easily moved up and down; ↑ significant increase/effect; = no effect; ↓ significant decrease

Effects of SSD in SB

The studies conducted by Dutta (2014), Daneshmandi (2021), and Metz (2023) suggest that SSD interventions significantly reduced sitting time. Dutta (2014) found that the SSD intervention group spent less time sitting and more time standing than the control group, resulting in increased EE. Daneshmandi (2021) results indicated an increased EE in the intervention groups compared to the baseline and control group. Additionally, Metz (2023) study demonstrated that the utilization of a walking desk (WD) significantly increased EE and METs compared to the standing or traditional desks, where the former two demonstrated to be similar.

Effects of SSD on dietary outcomes

Dutta (2014) found that the intervention group consumed fewer calories and had a lower macronutrient intake than the control group, in addition, reported a significant improvement in appetite sensations, leading to a lower hunger sensation and better control over prospective food consumption in the intervention group.

In contrast, the studies by Daneshmandi, Josephat, and Metz and colleagues which examined total energy intake (kilocalories), macronutrient intake, and satiety, demonstrated that both groups exhibited comparable effects. Additionally, the study by Josephat (2020) yielded consistent results regarding satiety quotient formulas for both groups. Metz (2023) showed a non-significant trend in appetite sensation, with the standing groups showing the lowest values.

DISCUSSION

As technology dominance increases, people spend more time sitting, particularly in front of screens (e.g., computers) (Boudet et al., 2019). Sedentary lifestyles pose significant deleterious effects on health, making it crucial to find ways to reduce it (Bull et al., 2020; Dey et al., 2023). This systematic review aimed to analyze the existing literature regarding the potential effect of SSD-based interventions on diet and eating behaviors. To the best of our knowledge, this is the first review that sought to gather and synthesize information about potential associations between sitting time reduction and eating behaviors.

The findings suggest that increasing standing time and light PA, while reducing sitting time potentially decreases appetite through neuroendocrine mechanisms, thus reducing caloric intake (Novak & Levine, 2007). Appetite and eating behaviors are controlled by a variety of

signals, deriving from leptin and insulin, and by a compound known as Lac-Phe (i.e., a downstream lactate and phenylalanine) responsible for appetite suppression (Caruso et al., 2023; Li et al., 2022). Change in response to food intake and appetite control can be influenced by exercise through hormone release and metabolism regulation (Ueda et al., 2009; Thackray & Stensel, 2023). It has been shown that light PA decreases the postprandial triglyceride concentration and increases fat oxidation the next day, whereas, conversely, PI and SB can trigger a metabolic state of inflexibility, which translates into the body's inability to alternate between the oxidation of lipids and carbohydrates (Chiu et al., 2020; Rynders et al., 2018). Adopting a low to moderate activity after a meal is key to improving postprandial glucose and regulating blood levels (Solomon et al., 2020). Therefore, although the evidence suggests that reducing sitting and replacing it with standing time through SSD intervention can potentially promote positive effects on eating behaviors, combining it with more intense PA may result in superior results.

The use of SSD effectively encourages an increase in standing time, as well as in light PA during working hours. Additionally, EE is higher when using a SSD compared to a traditional seated desk (Dutta et al., 2014; Daneshmandi et al., 2021; Benden et al., 2011). In comparison, notorious differences were found when using a walking desk (WD), which showed higher EE when compared with SSD (Metz et al., 2023). This finding suggests, that using WD, may be more efficient for improving eating behaviors, since in addition to reducing sitting time, these desks promote EE, which was previously showed to positively alter insulin response (Metz et al., 2023; Diaz et al., 2017; Podrekar et al., 2021).

In contrast to other studies, Dutta (2014) used a longer intervention period and it was carried out on a natural environment, which resulted in a perceptible reduction in food intake among participants in the intervention group, compared to the seated control group. These results suggest that working in an office environment, in a seated position, with intensive mental work, can potentially cause stress and encourage excessive energy intake increasing their consumption at the next meal (Beretta et al., 2023; Dutta et al., 2014; Michels et al., 2020). Also, Josaphat (2020) demonstrated a higher hunger sensation and prospective food consumption in the seated group, when compared to the group working with a SSD.

The utilization of SSD in the workplace and academic settings represents an efficacious methodology for the reduction of SB and the potential modulation of appetite sensations (Boudet et al., 2019; Ma et al., 2021). This outcome can be achieved by promoting and encouraging light PA, which has been demonstrated to influence the postprandial glycemic

index (Chiu et al., 2020; Rynders et al., 2018). These concomitant behaviors reflect the benefits at the metabolic level and also impact food choices throughout the day (Thackray & Stensel, 2023). It has been shown that WD and cycling desks produce more EE and, as a result, are more effective in this regard (Metz et al., 2023; Podrekar et al., 2021; Torbeyns et al., 2017).

To gain a more comprehensive understanding on how SSD can affect eating behaviors, further studies are needed, especially with larger samples, with the inclusion of participants from a diverse range of age, gender, and physical condition, and with more extended periods of observation in order to obtain more consistent results. Additionally, studies conducted in a realistic setting are essential for providing more reliable insights, as findings from studies in the laboratory context can hardly be translated to the real world.

Limitations

Several potential biases were identified in the studies included in this systematic review. Firstly, there were few studies that investigated the use of SSD with eating behaviors. Additionally, it should be noted that all studies had a relatively small sample size. Furthermore, the participants were all young and moderately active. Finally, it is important to consider that some experiments lasted for a too short period of time and were carried out in laboratory conditions that may not accurately reflect the true environment and the experiences of all workers.

CONCLUSION

The findings from this systematic review seem to indicate that the usage of SSD appears to favorably affect appetite sensations and the number of calories consumed. However, from the few studies identified, the results were far from being consistent, with half presenting a positive impact of SSD on dietary outcomes, while the other half showed no differences between the intervention and control groups. However, no study found a deleterious impact of SSD on dietary-related outcomes, thus SSD may represent a convenient, efficient, and autonomous strategy for interrupting prolonged periods of SB, with all the benefits associated with that “breaker” pattern, with no harms concerning the eating behaviors. More studies are needed to confirm these findings, especially with higher samples sizes and longer follow-up periods.

OTHER INFORMATION

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REFERENCES

Benden, M. E., Blake, J. J., Wendel, M. L., & Huber, J. C. (2011). The Impact of Stand-Biased Desks in Classrooms on Calorie Expenditure in Children. *American Journal of Public Health*, *101*(8), 1433–1436. https://doi.org/10.2105/AJPH.2010.300072

Beretta, V. S., Tebar, W. R., Scarabottolo, C. C., Delfino, L. D., Saraiva, B. T. C., Santos, A. B., Antunes, E. P., Leoci, I. C., Ferrari, G., & Christofaro, D. G. D. (2023). Association between Diet and Adiposity in Adults: Influence of Sedentary Behavior Patterns. *Healthcare*, *11*(8), 1157. https://doi.org/10.3390/healthcare11081157

Bonaccio, M., Iacoviello, L., De Gaetano, G., & On Behalf Of The Moli-sani Investigators. (2012). The Mediterranean diet: The reasons for a success. *Thrombosis Research*, *129*(3), 401–404. https://doi.org/10.1016/j.thromres.2011.10.018

Boudet, G., Chausse, P., Thivel, D., Rousset, S., Mermillod, M., Baker, J. S., Parreira, L. M., Esquirol, Y., Duclos, M., & Dutheil, F. (2019). How to Measure Sedentary Behavior at Work? *Frontiers in Public Health*, *7*, 167. https://doi.org/10.3389/fpubh.2019.00167

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J.-P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T., … Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, *54*(24), 1451–1462. https://doi.org/10.1136/bjsports-2020-102955

Caruso, L., Zauli, E., & Vaccarezza, M. (2023). Physical Exercise and Appetite Regulation: New Insights. *Biomolecules*, *13*(8), 1170. https://doi.org/10.3390/biom13081170

Cena, H., & Calder, P. C. (2020). Defining a Healthy Diet: Evidence for the Role of Contemporary Dietary Patterns in Health and Disease. *Nutrients*, *12*(2), 334. https://doi.org/10.3390/nu12020334

Chiu, C.-H., Chen, C.-H., Wu, M.-H., & Ding, Y.-F. (2020). Nonexercise Activity Thermogenesis-Induced Energy Shortage Improves Postprandial Lipemia and Fat Oxidation. *Life*, *10*(9), 166. https://doi.org/10.3390/life10090166

Daneshmandi, H., Choobineh, A., Ghaem, H., & Hejazi, N. (2021). Proper sit–stand work schedule to reduce the negative outcomes of sedentary behavior: A randomized clinical

trial. *International Journal of Occupational Safety and Ergonomics*, *27*(4), 1039–1055. https://doi.org/10.1080/10803548.2019.1679972

Dey, K. C., Zakrzewski-Fruer, J. K., Smith, L. R., Jones, R. L., & Bailey, D. P. (2023). Interrupting sitting acutely attenuates cardiometabolic risk markers in South Asian adults living with overweight and obesity. *European Journal of Applied Physiology*. https://doi.org/10.1007/s00421-023-05345-7

Diaz, K. M., Goldsmith, J., Greenlee, H., Strizich, G., Qi, Q., Mossavar-Rahmani, Y., Vidot, D. C., Buelna, C., Brintz, C. E., Elfassy, T., Gallo, L. C., Daviglus, M. L., Sotres-Alvarez, D., & Kaplan, R. C. (2017). Prolonged, Uninterrupted Sedentary Behavior and Glycemic Biomarkers Among US Hispanic/Latino Adults: The HCHS/SOL (Hispanic Community Health Study/Study of Latinos). *Circulation*, *136*(15), 1362–1373. https://doi.org/10.1161/CIRCULATIONAHA.116.026858

Dutta, N., Koepp, G., Stovitz, S., Levine, J., & Pereira, M. (2014). Using Sit-Stand Workstations to Decrease Sedentary Time in Office Workers: A Randomized Crossover Trial. *International Journal of Environmental Research and Public Health*, *11*(7), 6653–6665. https://doi.org/10.3390/ijerph110706653

Hamer, M., Yates, T., & Demakakos, P. (2017). Television viewing and risk of mortality: Exploring the biological plausibility. *Atherosclerosis*, *263*, 151–155. https://doi.org/10.1016/j.atherosclerosis.2017.06.024

Hellevik, S., Mustafa, S., Zhang, Y., Shirsat, A., & Saikat, S. (2023). Multisectoral action towards sustainable development goal 3.d and building health systems resilience during and beyond COVID-19: Findings from an INTOSAI development initiative and World Health Organization collaboration. *Frontiers in Public Health*, *11*, 1104669. https://doi.org/10.3389/fpubh.2023.1104669

Imran, T. F., Ommerborn, M., Clark, C., Correa, A., Dubbert, P., Gaziano, J. M., & Djoussé, L. (2018). Television Viewing Time, Physical Activity, and Mortality Among African Americans. *Preventing Chronic Disease*, *15*, 170247. https://doi.org/10.5888/pcd15.170247

Josaphat, K.-J., Labonté-Lemoyne, É., Sénécal, S., Léger, P.-M., & Mathieu, M.-E. (2020). Acute Impact of the Use of a Standing Desk on Appetite Sensations and Energy Intake. *Journal of Physical Activity and Health*, *17*(12), 1240–1246. https://doi.org/10.1123/jpah.2019-0444

King, A. C., Whitt-Glover, M. C., Marquez, D. X., Buman, M. P., Napolitano, M. A., Jakicic,

J., Fulton, J. E., & Tennant, B. L. (2019). Physical Activity Promotion: Highlights from the 2018 Physical Activity Guidelines Advisory Committee Systematic Review. *Medicine & Science in Sports & Exercise*, *51*(6), 1340–1353. https://doi.org/10.1249/MSS.0000000000001945

Kravitz and Vella. (2016). *Reducing sedentary behaviors: Sit less and move more*.

Kremers, S. P., De Bruijn, G.-J., Visscher, T. L., Van Mechelen, W., De Vries, N. K., & Brug, J. (2006). Environmental influences on energy balance-related behaviors: A dual-process view. *International Journal of Behavioral Nutrition and Physical Activity*, *3*(1), 9. https://doi.org/10.1186/1479-5868-3-9

Li, V. L., He, Y., Contrepois, K., Liu, H., Kim, J. T., Wiggenhorn, A. L., Tanzo, J. T., Tung, A. S.-H., Lyu, X., Zushin, P.-J. H., Jansen, R. S., Michael, B., Loh, K. Y., Yang, A. C., Carl, C. S., Voldstedlund, C. T., Wei, W., Terrell, S. M., Moeller, B. C., … Long, J. Z. (2022). An exercise-inducible metabolite that suppresses feeding and obesity. *Nature*, *606*(7915), 785–790. https://doi.org/10.1038/s41586-022-04828-5

Ma, J., Ma, D., Li, Z., & Kim, H. (2021). Effects of a Workplace Sit–Stand Desk Intervention on Health and Productivity. *International Journal of Environmental Research and Public Health*, *18*(21), 11604. https://doi.org/10.3390/ijerph182111604

Metz, L., Guirado, T., Beaulieu, K., Pereira, B., Brun, C., Coutarel, F., Duclos, M., & Thivel, D. (2023). Cognitive work on a walking desk does not lead to compensatory appetitive responses in healthy young adults. *Physiology & Behavior*, *258*, 114008. https://doi.org/10.1016/j.physbeh.2022.114008

Michels, N., Man, T., Vinck, B., & Verbeyst, L. (2020). Dietary changes and its psychosocial moderators during the university examination period. *European Journal of Nutrition*, *59*(1), 273–286. https://doi.org/10.1007/s00394-019-01906-9

Novak, C. M., & Levine, J. A. (2007). Central Neural and Endocrine Mechanisms of Non-Exercise Activity Thermogenesis and Their Potential Impact on Obesity. *Journal of Neuroendocrinology*, *19*(12), 923–940. https://doi.org/10.1111/j.1365-2826.2007.01606.x

Page, M. J., Moher, D., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … McKenzie, J. E. (2021). PRISMA 2020 explanation and elaboration: Updated guidance and exemplars for reporting systematic reviews. *BMJ*, n160.

https://doi.org/10.1136/bmj.n160

Park, J. H., Moon, J. H., Kim, H. J., Kong, M. H., & Oh, Y. H. (2020). Sedentary Lifestyle: Overview of Updated Evidence of Potential Health Risks. *Korean Journal of Family Medicine*, *41*(6), 365–373. https://doi.org/10.4082/kjfm.20.0165

Pistollato, F., Iglesias, R. C., Ruiz, R., Aparicio, S., Crespo, J., Lopez, L. D., Manna, P. P., Giampieri, F., & Battino, M. (2018). Nutritional patterns associated with the maintenance of neurocognitive functions and the risk of dementia and Alzheimer's disease: A focus on human studies. *Pharmacological Research*, *131*, 32–43. https://doi.org/10.1016/j.phrs.2018.03.012

Podrekar, N., Kozinc, Ž., & Šarabon, N. (2021). Effects of cycle and treadmill desks on energy expenditure and cardiometabolic parameters in sedentary workers: Review and meta-analysis. *International Journal of Occupational Safety and Ergonomics*, *27*(3), 728–736. https://doi.org/10.1080/10803548.2018.1562688

Rillamas-Sun, E., LaMonte, M. J., Evenson, K. R., Thomson, C. A., Beresford, S. A., Coday, M. C., Manini, T. M., Li, W., & LaCroix, A. Z. (2018). The Influence of Physical Activity and Sedentary Behavior on Living to Age 85 Years Without Disease and Disability in Older Women. *The Journals of Gerontology: Series A*, *73*(11), 1525–1531. https://doi.org/10.1093/gerona/glx222

Rynders, C. A., Blanc, S., DeJong, N., Bessesen, D. H., & Bergouignan, A. (2018). Sedentary behaviour is a key determinant of metabolic inflexibility. *The Journal of Physiology*, *596*(8), 1319–1330. https://doi.org/10.1113/JP273282

Solomon, T. P. J., Tarry, E., Hudson, C. O., Fitt, A. I., & Laye, M. J. (2020). Immediate post-breakfast physical activity improves interstitial postprandial glycemia: A comparison of different activity-meal timings. *Pflügers Archiv - European Journal of Physiology*, *472*(2), 271–280. https://doi.org/10.1007/s00424-019-02300-4

Shrestha, N., Kukkonen-Harjula, K. T., Verbeek, J. H., Ijaz, S., Hermans, V., & Bhaumik, S. (2016). Workplace interventions for reducing sitting at work. *Cochrane Database of Systematic Reviews*. https://doi.org/10.1002/14651858.CD010912.pub3

Thackray, A. E., & Stensel, D. J. (2023). The impact of acute exercise on appetite control: Current insights and future perspectives. *Appetite*, *186*, 106557. https://doi.org/10.1016/j.appet.2023.106557

Torbeyns, T., De Geus, B., Bailey, S., Decroix, L., Van Cutsem, J., De Pauw, K., & Meeusen, R. (2017). Bike Desks in the Classroom: Energy Expenditure, Physical Health,

Cognitive Performance, Brain Functioning, and Academic Performance. *Journal of Physical Activity and Health*, *14*(6), 429–439. https://doi.org/10.1123/jpah.2016-0224

Ueda, S., Yoshikawa, T., Katsura, Y., Usui, T., & Fujimoto, S. (2009). Comparable effects of moderate intensity exercise on changes in anorectic gut hormone levels and energy intake to high intensity exercise. *Journal of Endocrinology*, *203*(3), 357–364. https://doi.org/10.1677/JOE-09-0190

Zhao, R., Bu, W., Chen, Y., & Chen, X. (2020). The Dose-Response Associations of Sedentary Time with Chronic Diseases and the Risk for All-Cause Mortality Affected by Different Health Status: A Systematic Review and Meta-Analysis. *The Journal of Nutrition, Health & Aging*, *24*(1), 63–70. https://doi.org/10.1007/s12603-019-1298-3

CHAPTER III

The impact of a sit-stand desk intervention on eating behaviors: results from the SUFHA clustered RCT

ABSTRACT

Background: It has been observed that populations who adhere to a Mediterranean dietary pattern demonstrate a significant reduction in mortality rates from non-communicable diseases (NCD) and greater longevity. The implementation of sit-stand desks (SSD) has been demonstrated to be an efficacious strategy for interrupting prolonged periods of sedentary behavior (SB). This approach has been shown to increase EE, enhance daily PA, and has the potential to modify the microenvironment, by influencing workers' eating behaviors. The aim of this study was to analyze the impact of a 6-month SSD intervention, the Stand Up for Healthy Aging (SUFHA) cluster randomized controlled trial, on eating behaviors.

Methods: The study involved two groups of office workers from the University of Lusófona and was conducted in the participants' work environment over a six-month period. The study included 38 participants that attended a psychoeducational session at baseline and then half of them (i.e., intervention group) used the SSD while the control group continued working in their traditional desks. All participants were assessed at baseline and at the end of the 6 months, using an 11-item questionnaire to assess the adherence to the Mediterranean diet.

Results: The results demonstrated a significant difference between the two groups at baseline, only for the fish consumption (p=0.043), favoring the intervention group. At six months, the intervention group exhibited enhanced adherence to the Mediterranean diet (+3.37 score) (p=0.013), consumption of fish (+0.79 portions/week) (p=0.022), and consumption of vegetables (+1.0 portions/week) (p=0.002), in comparison to the control group.

Conclusion: The relationship between SSD and eating behaviors is a relatively new area of research, with a notable lack of studies examining how SSD can influence eating behaviors. The use of SSD has come under increasing scrutiny with the goal of establishing their effectiveness as a tool to reduce and interrupt SB and improve health outcomes. Our results suggest that accessibility to SSD may potentially promote healthier food selection and increase adherence to a Mediterranean-style diet, which is associated with numerous health advantages. However, given the dearth of studies on this topic, further research is required to substantiate these findings.

Keywords: Sit-stand desk; sedentary time; diet; standing time; dietary intake.

INTRODUCTION

The Mediterranean Diet has its origins in the regions bordering the Mediterranean Sea. These include countries such as Portugal, Spain, Morocco, Italy, Greece, Cyprus, and Croatia. In 2010, the Mediterranean Diet was recognized by UNESCO as Intangible Cultural Heritage of Humanity (Trichopoulou, 2021). The term "diet" has etymological roots in the Greek "diaita," which translates to "way of life". In the 1950s, Ancel Keys' work established the largely vegetable-based Mediterranean diet as the prototype for today's dietary guidelines Dominguez et al., 2021).

The UNESCO recognition highlights these long-loved and recognized culinary practices as part of a wider popular culture. This culture is characterized by the quality, simplicity and healthiness of indigenous foods, combined with popular eating behaviors, territoriality, biodiversity and full respect and consideration for seasonality (Saulle & La Torre, 2010). The Mediterranean diet is not merely a nutritional regime, it is, rather, a culture, a tradition and an exemplification of high-quality, sustainable "art" (Saulle & La Torre, 2010). A number of authors have identified the following dietary pattern as the foundation of this diet, a high consumption of vegetables, pulses (beans, lentils, etc.), fruit and cereals; a medium-high consumption of fish; a low consumption of meat and saturated fats; a high consumption of unsaturated fats (especially olive oil); a medium-low consumption of dairy products (especially yoghurt and cheese); and a moderate consumption of wine (Ricco et al., 2024).

Populations that adhere to a Mediterranean dietary pattern have been observed to exhibit a 50% reduction in mortality rates from cardiovascular diseases and a greater longevity, which favor’s the primary prevention of the main chronic diseases and the improvement of health status (Becerra-Tomás et al., 2020). Furthermore, social and cultural factors, such as cooking and socializing, as well as PA patterns, sedentary and rest habits, and dietary practices, also contribute to the longevity observed in these populations . The Blue Zones, which include Sardinia (Italy) and Ikaria (Greece), serve as excellent exemplars of the sociocultural factors that shape eating behaviors. Their distinctive characteristics remain a topic of ongoing scholarly debate (Gil, 2015; Pes et al., 2022). However, it can be posited that the environmental factors and the accessibility of food play a pivotal role in determining dietary choices (Bonaccio et al., 2012; Kremers et al., 2006). One potential barrier preventing the adoption of healthy diets is the higher cost associated with such diets. However, reducing consumption of food components

not representative of a Mediterranean diet, including high-calorie snacks and fast food, while substituting with less expensive, yet nutritionally lacking, options can help to offset these costs (Tong et al., 2018; Bonaccio et al., 2012).

The data indicate that the majority of the World Health Organization's (WHO) objectives for noncommunicable diseases (NCDs) are unlikely to be achieved by 2025. Furthermore, the prevalence of PI is estimated to affect approximately one in three adults residing in the European Society of Cardiology (ESC) member countries. The observed increase in sedentary time, including extended periods spent sitting at work, leisure activities, and in front of a computer, is not aligned with current recommendations (Ross et al., 2020). These recommendations indicate that recreational screen time should be limited to less than two hours a day and are associated with unhealthy eating behaviors (Giménez-Legarre et al., 2019; Trott et al., 2022). In countries with a high-income level, eating behaviors that are positively associated with cardiovascular disease (CVD) are more common than those that are negatively associated. These include diets that contain high amounts of trans fats and added sugars (Timmis et al., 2022).

The implementation of sit-stand desks (SSD) has been demonstrated as an efficacious strategy for disrupting extended periods of inactivity. This approach has been shown to increase EE, enhance daily PA and has the potential to modify the microenvironment, influencing workers' eating behaviors (Dutta et al., 2014; Josaphat et al., 2020; Metz et al., 2023).

Its notorious the gap in literature about the direct link between SSD based interventions and its impact on eating behaviors, then the aim of this study is to analyze the impact of a SSD intervention for 6 months - Stand Up for Healthy Aging (SUFHA) cluster randomized controlled trial (Júdice et al., 2023) - on eating behaviors. The study will specifically examine the responses provided to the questionnaire on the adherence to the Mediterranean diet, as outlined by Panagiotakos and colleagues (2007), which was administered on both the control group (those who continue working on their traditional sitting desks) and the intervention group (those who used SSD).

METHODS

Study design

A parallel-group superiority clustered randomized control trial (RCT) was conducted with two groups of office workers from the Lusófona University. The trial spanned six months and was conducted in the participants' actual work environment. To facilitate informed consent

and enhance engagement with the trial, a digital resource was created: a website containing comprehensive trial information, evaluation materials, and strategies to encourage SSD usage. This website can be accessed via the following link: https://sufha.ulusofona.pt/. At the outset of the study, all participants were given a psycho-educational session led by an expert in this field of research, during which the potential benefits of reducing and interrupting periods of sitting with activities that involve standing or other movements were discussed. Subsequently, only those individuals who had consented to participate in an intervention were given the opportunity to engage with the SSD in addition to receiving prompts and information regarding sedentary behaviors reduction and the use of sit-stand desks. Any queries raised by these participants were addressed before the written informed consent form was signed. The intervention was considered low risk, and therefore, interim analyses and formal stopping rules were not deemed necessary by the research team.

Participants and Recruitment

The inclusion criteria were being more than 20 years old, spending at least 70% of a working week performing desk-related activities, not have musculoskeletal disorders/health conditions making it impossible to work in a standing posture. Opportunity to have a SSD in their workplace (Vinsetto, Model 923-043, which was installed on top of a conventional workplace desk by means of a clamping arm), allowing them to work seated or standing and change between these postures as many times as they desire. Also, participants could not be using an SSD prior to the intervention.

Data Collection

Eating behaviors were assessed using an 11-item original questionnaire evaluating the adherence to the Mediterranean diet (Panagiotakos et al., 2007), in which the participants reported the weekly consumption of 9 food groups (i.e., non-refined cereals, fruits, vegetables, legumes, potatoes, fish, meat and meat products, poultry, and full-fat dairy products including cheese), plus olive oil use in cooking and alcoholic beverage intake, based on the principles of the traditional Mediterranean Diet, on a scale of 0 to 5 (never, rare, frequent, very frequent, weekly, and daily consumption), and then a composite score was calculated. The age of the participants was obtained through self-declaration using an online questionnaire. Height was

determined with precision to the nearest 0.1 cm through the utilization of a stadiometer (Seca, Hamburg, Germany).

Participants were weighed to the nearest 0.01 kg, in the absence of footwear and wearing minimal clothing, on an electronic scale (TANITA BC-601 scale). Body mass index (BMI) was calculated as body mass (kg)/height²(m).

The outcomes were assessed at baseline and 6 months for the whole sample.

Data Analysis

Statistical analyses were performed using PASW Statistics for Windows version 29.0 (SPSS Inc., an IBM Company, Chicago IL, USA) and statistical significance was set at 5%. To evaluate the effects of the intervention on the main outcomes (eating behaviors and adherence to the Mediterranean diet), One-way ANOVAs were used, to compare the two groups at baseline and then at 6-month follow-up.

Ethical approval

The project was approved by the ethics commission of the Faculty of Physical Education and Sport at the University of Lusófona in Lisbon (Approval number D0522). All participants provided written informed consent prior to their participation.

RESULTS

The characteristics of the sample at baseline are presented on table 3. To assess whether there were significant differences between the two groups, a one-way ANOVA was employed. The resulting P-values indicated no differences between groups at baseline, indicating that the two groups were comparable.

Table 3 - Baseline characteristics of both randomized groups: usual practice (control) and SUFHA intervention. Values are means ± standard deviations.

Characteristics	Control (n=19)	Intervention (n=19)	P-value
Age (years)	42.26 ± 9.51	45.68 ± 5.91	0.191
Height (m)	164.13 ± 8.19	162.87 ± 8.84	0.650
Body mass (kg)	82.29 ± 21.09	72.60 ± 16.80	0.126
BMI (kg/m^2)	30.50 ± 7.43	27.36 ± 6.20	0.165
Sitting Time (min/day)	475.87 ± 130.43	471.39 ± 71.56	0.896

Standing Time (min/day)	248.37 ± 82.19	278.29 ± 93.13	0.301
Total Number Steps per day	6519.21 ± 2239.69	7992.79 ± 2500.65	0.064

BMI- Body Mass Index.
Note: The p-values come from the one way ANOVA.

Table 4 shows the main outcomes of this study at baseline and 6 months for both groups.

Table 4 - Differences between groups at baseline and 6 months for the main outcomes.

Mediterranean Diet questionnaire	**Baseline**			**6 Months**		
	Control (n=19)	**Intervention (n=19)**	**P-value**	**Control (n=19)**	**Intervention (n=19)**	**P-value**
Unrefined cereals (portions/week)	1.79 ± 1.27	1.47 ± 0.84	0.373	1.37 ± 0.90	1.05 ± 0.78	0.254
Potatoes (portions/week)	2.42 ± 0.69	2.26 ± 0.87	0.540	2.53 ± 0.84	2.16 ± 0.96	0.216
Fruit (portions/week)	2.21 ± 1.51	2.42 ± 0.96	0.612	2.11 ± 1.20	2.63 ± 1.17	0.178
Vegetables (portions/week)	1.74 ± 0.93	2.05 ± 1.08	0.341	1.42 ± 0.70	2.42 ± 1.07	**0.002***
Legumes (portions/week)	2.26 ± 1.28	2.00 ± 0.88	0.466	2.11 ± 1.15	2.37 ± 0.76	0.411
Fish (portions/week)	2.05 ± 1.08	2.79 ± 1.08	**0.043***	2.05 ± 1.10	2.84 ± 0.96	**0.022***
Red meat (portions/week)	1.47 ± 1.26	1.37 ± 1.07	0.783	1.21 ± 0.71	1.26 ± 0.93	0.846
White meat (portions/week)	1.74 ± 1.24	1.32 ± 1.06	0.267	1.68 ± 1.16	1.42 ± 0.84	0.427
Full-fat dairy products (portions/week)	0.58 ± 1.17	0.58 ± 0.90	1.000	0.42 ± 0.69	0.53 ± 0.77	0.661
Use of olive oil in cooking (times/week)	4.42 ± 0.84	4.79 ± 0.54	0.115	4.32 ± 0.95	4.42 ± 1.12	0.756
Alcoholic drinks (ml/day)	4.26 ± 1.63	3.68 ± 2.26	0.371	4.11 ± 1.88	2.84 ± 2.41	0.080
Score Adherence to the Mediterranean Diet	28.84 ± 4.15	30.84 ± 4.60	0.168	28.47 ± 3.20	31.84 ± 4.59	**0.013***

*Significant differences between groups based on the one way ANOVA at each moment.

Table 4 demonstrates that at the outset, a single discrepancy was identified between groups, specifically regarding fish consumption with a difference of (+0.47 portions/week) (p=0.043), with the intervention group presenting a higher consumption. At the 6-month follow-up, further differences were observed regarding vegetable consumption with a difference of

(+1.0 portions/week) (p=0.002), fish consumption (+0.79 portions/week) (p=0.022), and adherence to the Mediterranean diet with a difference of (+3.37 score) (p=0.013).

DISCUSSION

The relationship between SSD and eating behaviors represents a relatively embryonic field of research, despite the fact it is already the topic of very few studies. There is a notable absence of studies that examine how SSD influence eating behaviors. Consistent with the findings of Dutta et al. (2014), who documented decreased calories consumed in the intervention group, our study suggests an increased intake of healthier foods (fish, vegetables, translating to a higher score of adherence to the mediterranean diet). In contrast, other studies (Josaphat et al., 2020; Daneshmandi et al., 2021; Metz et al., 2023) that have examined the relationship between SSD and eating behaviors have found no differences in dietary outcomes between groups.

The use of SSD has been the subject of increasing scrutiny with the goal of establishing their efficacy as a tool for reducing and interrupting SB (Smith et al., 2015; Shrestha et al., 2016; Weatherson et al., 2020). The findings revealed an advancement and enhancement in dietary habits amongst the intervention group. This was accompanied by a concurrent reduction in SB, an augmentation in PA levels, and an elevated consciousness of associated salutary habits. These factors collectively contributed to the observed dietary outcomes, both regarding specific food groups (fish and veggie intake) and in terms of adherence to the Mediterranean diet as a unified outcome. Overall adherence to the Mediterranean diet, which reflects a dietary concern with positive effects, was observed.

The aim is to facilitate change and foster a comprehensive, conscious, and tangible understanding among organizations and governments of the necessity for transformative change and the implementation of sustainable solutions to enhance mobility behaviors, well-being, and the reduction of non-communicable diseases (NCDs) and the costs associated with them (Dempsey et al., 2016; Young et al., 2016). In addition to the fact that EE in the standing position exerts a significant influence, prolonging this stance during work has been linked to strategies with the potential for markedly favorable effects on weight management and maintaining a healthy weight. This approach entails reshaping the environment that fosters overeating and underactivity (Saeidifard et al., 2018; Nyhus Dhillon & Ortenzi, 2023).

The term NEAT stands for non-exercise activity thermogenesis and represents the main variable component of total daily EE. This term is used to describe the part of daily EE resulting

from spontaneous PA that does not result especially from voluntary exercise. It could explain why some individuals who are predisposed to developing obesity tend to engage in sedentary activities and eat more than their energy needs. The interplay of environmental and biological factors, shaped by an individual's occupational and recreational pursuits, along with molecular and genetic variations, can significantly influence EE and eating behaviors (Levine et al., 1999; Chung et al., 2018; Rizzato et al., 2022).

In addition to the potential benefits of SSD (Healy et al., 2016), other researchers have not found significant correlations between the use of SSD and changes in eating behaviors (Josaphat et al., 2020; Daneshmandi et al., 2021; Metz et al., 2023). However, these findings may lead to an optimistic view of SSD use in interrupting and reducing SB, while encouraging more light activity and frequent breaks. Where the disruption of routine encourages users to take more frequent breaks. This could disrupt habitual snacking patterns, for example (Kono et al., 2023). This could lead to either a reduction in unnecessary eating or, conversely, an increase in eating during breaks due to altered routines (Villablanca et al., 2015; Hamilton et al., 2018). The data obtained in this study, in terms of its length, real-world context, and primary focus, demonstrate a noteworthy depth of interest and engagement with SSD among the researchers involved. Of note is the convergence of nutrition, which has emerged as a distinctive area of innovation and interest, with a view to enriching the existing body of literature on this subject. This has the potential to empower SSD users, enabling them to make informed decisions and contribute to improved population health.

Limitations

The sample size was relatively limited, as it was not calculated based on the dietary derived outcomes. The baseline measurements were conducted during the winter months (January), while the six-month follow-up measurements were taken in the summer. This temporal discrepancy could potentially introduce bias into the results, given the inherent differences between the two seasons. However, the study design (including a control group) can somehow eliminate this bias. The completion of the questionnaire is facilitated by a trained evaluator who helped in its completion and interpretation. However, the accuracy of the results is dependent on the individual's ability to accurately recall their dietary intake. Therefore, alternative methods, such as food records or food diaries, may provide a more reliable representation of the results. Further investigation should be conducted to elucidate the following aspects: the applicability of the findings to other work contexts; the impact of sex on the results.

CONCLUSION

Following a six-month intervention period, individuals with access to SSD exhibited a more favorable dietary pattern, characterized by a higher consumption of vegetables and fish, resulting in a superior adherence to the Mediterranean diet, in comparison to the control group. The findings indicate that the accessibility of SSD can possibly foster healthier dietary selections and enhance the adherence to a Mediterranean-style diet, which correlates with a multitude of health advantages. However, given the lack of studies on this topic, more investigation is needed to confirm these findings. Organizations and governments can play a pivotal role in the prevention of NCD and the promotion of an active and health-conscious workforce, as strategies for tackling some deleterious behaviors (i.e., sitting time) may simultaneously help participants attain other health benefits (i.e., dietary intake).

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REFERENCES

Becerra-Tomás, N., Blanco Mejía, S., Viguiliouk, E., Khan, T., Kendall, C. W. C., Kahleova, H., Rahelić, D., Sievenpiper, J. L., & Salas-Salvadó, J. (2020). Mediterranean diet, cardiovascular disease and mortality in diabetes: A systematic review and meta-analysis of prospective cohort studies and randomized clinical trials. *Critical Reviews in Food Science and Nutrition*, *60*(7), 1207–1227. https://doi.org/10.1080/10408398.2019.1565281

Bonaccio, M., Iacoviello, L., De Gaetano, G., & On Behalf Of The Moli-sani Investigators. (2012). The Mediterranean diet: The reasons for a success. *Thrombosis Research*, *129*(3), 401–404. https://doi.org/10.1016/j.thromres.2011.10.018

Chung, N., Park, M.-Y., Kim, J., Park, H.-Y., Hwang, H., Lee, C.-H., Han, J.-S., So, J., Park, J., & Lim, K. (2018). Rizzato. *Journal of Exercise Nutrition & Biochemistry*, *22*(2), 23–30. https://doi.org/10.20463/jenb.2018.0013

Daneshmandi, H., Choobineh, A., Ghaem, H., & Hejazi, N. (2021). Proper sit–stand work schedule to reduce the negative outcomes of sedentary behavior: A randomized clinical trial. *International Journal of Occupational Safety and Ergonomics*, *27*(4), 1039–1055. https://doi.org/10.1080/10803548.2019.1679972

Dempsey, P. C., Owen, N., Yates, T. E., Kingwell, B. A., & Dunstan, D. W. (2016). Sitting Less and Moving More: Improved Glycaemic Control for Type 2 Diabetes Prevention and Management. *Current Diabetes Reports*, *16*(11), 114. https://doi.org/10.1007/s11892-016-0797-4

Dominguez, L. J., Di Bella, G., Veronese, N., & Barbagallo, M. (2021). Impact of Mediterranean Diet on Chronic Non-Communicable Diseases and Longevity. *Nutrients*, *13*(6), 2028. https://doi.org/10.3390/nu13062028

Dutta, N., Koepp, G., Stovitz, S., Levine, J., & Pereira, M. (2014). Using Sit-Stand Workstations to Decrease Sedentary Time in Office Workers: A Randomized Crossover Trial. *International Journal of Environmental Research and Public Health*, *11*(7), 6653–6665. https://doi.org/10.3390/ijerph110706653

Gil, Á. (2015). Indicadores de evaluación de la calidad de la dieta. *NUTRICION HOSPITALARIA*, *3*, 128–144. https://doi.org/10.3305/nh.2015.31.sup3.8761

Giménez-Legarre, N., Santaliestra-Pasías, A. M., Beghin, L., Dallongeville, J., De La O, A., Gilbert, C., González-Gross, M., De Henauw, S., Kafatos, A., Kersting, M., Leclerq, C., Manios, Y., Molnar, D., Sjöström, M., Widhalm, K., Huybrechts, I., Moreno, L. A., & on behalf of the HELENA Study Group. (2019). Dietary Patterns and Their Relationship With the Perceptions of Healthy Eating in European Adolescents: The HELENA Study. *Journal of the American College of Nutrition*, *38*(8), 703–713. https://doi.org/10.1080/07315724.2019.1598900

Hamilton, M. T., Hamilton, D. G., & Zderic, T. W. (2018). The Necessity of Active Muscle Metabolism for Healthy Aging: Muscular Activity Throughout the Entire Day. In *Progress in Molecular Biology and Translational Science* (Vol. 155, pp. 53–68). Elsevier. https://doi.org/10.1016/bs.pmbts.2017.12.014

Healy, G. N., Eakin, E. G., Owen, N., Lamontagne, A. D., Moodie, M., Winkler, E. A. H., Fjeldsoe, B. S., Wiesner, G., Willenberg, L., & Dunstan, D. W. (2016). A Cluster

Randomized Controlled Trial to Reduce Office Workers' Sitting Time: Effect on Activity Outcomes. *Medicine & Science in Sports & Exercise*, *48*(9), 1787–1797. https://doi.org/10.1249/MSS.0000000000000972

Júdice, P. B., Carraça, E. V., Santos, I., Palmeira, A. L., Jerónimo, F., & Silva, M. N. (2024). Different sedentary behavior domains present distinct associations with eating-related indicators. *BMC Public Health*, *24*(1), 275. https://doi.org/10.1186/s12889-024-17760-2

Júdice, P. B., Silva, H., Teno, S. C., Monteiro, P., Silva, M. N., Carraça, E. V., Santos, I., Pereira, S., Luz, F., Viegas, P. C., Oliveira, J., Santos, I. F., & Palmeira, A. L. (2023). Providing office workers with height-adjustable workstation to reduce and interrupt workplace sitting time: Protocol for the Stand Up for Healthy Aging (SUFHA) cluster randomized controlled trial. *Trials*, *24*(1), 381. https://doi.org/10.1186/s13063-023-07407-9

Kremers, S. P., De Bruijn, G.-J., Visscher, T. L., Van Mechelen, W., De Vries, N. K., & Brug, J. (2006). Environmental influences on energy balance-related behaviors: A dual-process view. *International Journal of Behavioral Nutrition and Physical Activity*, *3*(1), 9. https://doi.org/10.1186/1479-5868-3-9

Kono, H., Furuta, K., Sakamoto, T., & Ueda, S. (2023). Effects of Standing after a Meal on Glucose Metabolism and Energy Expenditure. *International Journal of Environmental Research and Public Health*, *20*(20), 6934. https://doi.org/10.3390/ijerph20206934

Levine, J. A. (2015). Sick of sitting. *Diabetologia*, *58*(8), 1751–1758. https://doi.org/10.1007/s00125-015-3624-6

Metz, L., Guirado, T., Beaulieu, K., Pereira, B., Brun, C., Coutarel, F., Duclos, M., & Thivel, D. (2023). Cognitive work on a walking desk does not lead to compensatory appetitive responses in healthy young adults. *Physiology & Behavior*, *258*, 114008. https://doi.org/10.1016/j.physbeh.2022.114008

Nyhus Dhillon, C., & Ortenzi, F. (2023). Assessing the Impact of Workforce Nutrition Programmes on Nutrition, Health and Business Outcomes: A Review of the Global Evidence and Future Research Agenda. *International Journal of Environmental Research and Public Health*, *20*(9), 5733. https://doi.org/10.3390/ijerph20095733

Panagiotakos, D. B., Pitsavos, C., Arvaniti, F., & Stefanadis, C. (2007). Adherence to the Mediterranean food pattern predicts the prevalence of hypertension, hypercholesterolemia, diabetes and obesity, among healthy adults; the accuracy of the

MedDietScore. *Preventive Medicine*, *44*(4), 335–340. https://doi.org/10.1016/j.ypmed.2006.12.009

Pes, G. M., Dore, M. P., Tsofliou, F., & Poulain, M. (2022). Diet and longevity in the Blue Zones: A set-and-forget issue? *Maturitas*, *164*, 31–37. https://doi.org/10.1016/j.maturitas.2022.06.004

Ricco, A., Chiaradia, G., Piscitelli, M., & La Torre, G. (2024). The effects of Mediterranean Diet on Cardiovascular diseases: A systematic review. *Italian Journal of Public Health*, *4*(2). https://doi.org/10.2427/5887

Rizzato, A., Marcolin, G., & Paoli, A. (2022). Kono. *Frontiers in Public Health*, *10*, 1024856. https://doi.org/10.3389/fpubh.2022.1024856

Ross, R., Chaput, J.-P., Giangregorio, L. M., Janssen, I., Saunders, T. J., Kho, M. E., Poitras, V. J., Tomasone, J. R., El-Kotob, R., McLaughlin, E. C., Duggan, M., Carrier, J., Carson, V., Chastin, S. F., Latimer-Cheung, A. E., Chulak-Bozzer, T., Faulkner, G., Flood, S. M., Gazendam, M. K., … Tremblay, M. S. (2020). Canadian 24-Hour Movement Guidelines for Adults aged 18–64 years and Adults aged 65 years or older: An integration of physical activity, sedentary behaviour, and sleep. *Applied Physiology, Nutrition, and Metabolism*, *45*(10 (Suppl. 2)), S57–S102. https://doi.org/10.1139/apnm-2020-0467

Saeidifard, F., Medina-Inojosa, J. R., Supervia, M., Olson, T. P., Somers, V. K., Erwin, P. J., & Lopez-Jimenez, F. (2018). Differences of energy expenditure while sitting versus standing: A systematic review and meta-analysis. *European Journal of Preventive Cardiology*, *25*(5), 522–538. https://doi.org/10.1177/2047487317752186

Saulle, R., & La Torre, G. (2010). The Mediterranean Diet, recognized by UNESCO as a cultural heritage of humanity. *Italian Journal of Public Health*, *7*(4). https://doi.org/10.2427/5700

Shrestha, N., Kukkonen-Harjula, K. T., Verbeek, J. H., Ijaz, S., Hermans, V., & Bhaumik, S. (2016). Workplace interventions for reducing sitting at work. *Cochrane Database of Systematic Reviews*. https://doi.org/10.1002/14651858.CD010912.pub3

Smith, L., Ekelund, U., & Hamer, M. (2015). The Potential Yield of Non-Exercise Physical Activity Energy Expenditure in Public Health. *Sports Medicine*, *45*(4), 449–452. https://doi.org/10.1007/s40279-015-0310-2

Timmis, A., Vardas, P., Townsend, N., Torbica, A., Katus, H., De Smedt, D., Gale, C. P., Maggioni, A. P., Petersen, S. E., Huculeci, R., Kazakiewicz, D., Rubio, V. D. B.,

Ignatiuk, B., Raisi-Estabragh, Z., Pawlak, A., Karagiannidis, E., Treskes, R., Gaita, D., Beltrame, J. F., … Achenbach, S. (2022). European Society of Cardiology: Cardiovascular disease statistics 2021: Executive Summary. *European Heart Journal - Quality of Care and Clinical Outcomes*, *8*(4), 377–382. https://doi.org/10.1093/ehjqcco/qcac014

Tong, T. Y. N., Imamura, F., Monsivais, P., Brage, S., Griffin, S. J., Wareham, N. J., & Forouhi, N. G. (2018). Dietary cost associated with adherence to the Mediterranean diet, and its variation by socio-economic factors in the UK Fenland Study. *British Journal of Nutrition*, *119*(6), 685–694. https://doi.org/10.1017/S0007114517003993

Trichopoulou, A. (2021). Mediterranean diet as intangible heritage of humanity: 10 years on. *Nutrition, Metabolism and Cardiovascular Diseases*, *31*(7), 1943–1948. https://doi.org/10.1016/j.numecd.2021.04.011

Trott, M., Driscoll, R., Iraldo, E., & Pardhan, S. (2022). Changes and correlates of screen time in adults and children during the COVID-19 pandemic: A systematic review and meta-analysis. *eClinicalMedicine*, *48*, 101452. https://doi.org/10.1016/j.eclinm.2022.101452

Villablanca, P. A., Alegria, J. R., Mookadam, F., Holmes, D. R., Wright, R. S., & Levine, J. A. (2015). Nonexercise Activity Thermogenesis in Obesity Management. *Mayo Clinic Proceedings*, *90*(4), 509–519. https://doi.org/10.1016/j.mayocp.2015.02.001

Weatherson, K. A., Wunderlich, K. B., & Faulkner, G. E. (2020). Impact of a low-cost standing desk on reducing workplace sitting (StandUP UBC): A randomised controlled trial. *Applied Ergonomics*, *82*, 102951. https://doi.org/10.1016/j.apergo.2019.102951

Young, D. R., Hivert, M.-F., Alhassan, S., Camhi, S. M., Ferguson, J. F., Katzmarzyk, P. T., Lewis, C. E., Owen, N., Perry, C. K., Siddique, J., & Yong, C. M. (2016). Sedentary Behavior and Cardiovascular Morbidity and Mortality: A Science Advisory From the American Heart Association. *Circulation*, *134*(13). https://doi.org/10.1161/CIR.0000000000000440

CHAPTER IV

GENERAL DISCUSSION

As reported by the World Health Organization, approximately 3.2 million deaths per year are attributable to a sedentary lifestyle. In 2022, one in eight individuals was affected by obesity, while 2.5 billion adults (aged 18 and above) were classified as overweight (Strain et al., 2024).

The findings deriving from the conjunction of the two investigations conducted in this thesis suggest some importance of SSD in nutrition of sedentary office workers. The reduction of sitting time in conjunction with an increase in standing time through SSD intervention seems to have the potential to engender favorable effects on dietary habits.

The utilization of SSD effectively encourages an increase in standing time, as well as in low intensity PA during working hours (Michalchuk et al., 2022). Furthermore, EE in the standing position exerts a modest influence, showing modest energetic costs regardless of sex and body composition, and can become pronounced when this practice is maintained over an extended period (Júdice et al., 2016; Saeidifard et al., 2018; Nakagata et al., 2019; Saeidifard et al., 2018). The prolongation of the seated position during the workday has been found to contribute to an environment that fosters overeating and underactivity (Daneshmandi et al., 2021; Nyhus Dhillon & Ortenzi, 2023). The act of maintained sitting can exert a psychological influence on the individual, prompting to engage in fewer movements and consume food in a less healthy and more excessive manner (Josaphat et al., 2020; Alosaimi et al., 2023).

Individuals who experience elevated levels of stress also demonstrate a diminished capacity to regulate their eating behaviors. In the workplace, intense mental work may have the potential to induce stress and promote excessive energy intake, which in turn can increase subsequent meal consumption (Tan & Chow, 2014; Dutta et al., 2014; Michels et al., 2020). It is also crucial to engage in low to moderate physical activity following a meal. This can effectively enhance postprandial glycemia and regulate blood levels, which has beneficial implications for metabolism and influences food choices across the day. This is because exercise prompts changes in the production of the appetite hormone ghrelin. The reduction in

circulating ghrelin resulting from prior physical exertion has been linked to diminished cravings for sweet and unhealthy foods. Additionally, it has been observed that such exertion fosters greater cognitive restraint with regard to less healthy dietary choices (Rocha et al., 2016; Leow et al., 2021; Solomon et al., 2020; Thackray & Stensel, 2023).

In addition to these effects, SSD have been shown to contribute to positive outcomes with regard to health in the workplace and subjective well-being, as well as reducing instances of neck and shoulder discomfort, improving work efficiency, productivity, and commitment at work, and positively affecting self-assessment (Ma et al., 2021; Chau et al., 2016; Arguello et al., 2023), thus contributing to less stress and therefore, potential eating behaviors.

These factors combine to provide numerous reasons for the implementation of various small-scale options that contribute to the creation of an encouraging work environment. Such an environment can promote health and well-being of employees, and the incentive to interrupt SB with the use of SSD contributes to this change in the work context. This is evidenced by the results presented in the systematic review. A reduction in feelings of hunger and desire to eat was observed in the intervention group (Dutta et al., 2014; Josaphat et al., 2020). These findings are consistent with those from our original study, which demonstrated a higher adherence to the Mediterranean diet and an increase in nutritional awareness and consumption of healthier foods, including fish and vegetables in the intervention group.

The data suggests that increased accessibility to SSD may potentially encourage healthier dietary selections with a multitude of health benefits. These include reduced time spent sitting, increased time standing, and consequently, enhanced light physical activity, as well as enhanced nutritional awareness, which is associated with improved dietary choices.

Limitations

To gain a deeper insight into the impact of SSD on eating behaviors, further research is necessary. Specifically, larger samples and longer observation periods are required to assess and quantify nutritional data. Additionally, employing alternative methods, such as food records or diaries, and increasing the frequency of data collection during the studies will enhance our understanding of the phenomenon under study.

GENERAL CONCLUSION

Although SSDs at first sight may seem a relatively low-impact intervention, the extant evidence suggests that they can facilitate the desired physical behavioral changes with benefits in terms of well-being, and according to the findings of this thesis, the benefits may extend to the nutritional field. The use of SSD demonstrated to enhance the dietary habits of office-based employees, who frequently spend most of the workday in a seated position. Modifying the working environment in general and adopting progressive measures, including the use of SSD, may represent an effective approach to counteract some health problems such as obesity, with quantifiable and achievable results for the population. This can be achieved by encouraging a break from prolonged periods of SB and promoting low intensity but essential physical activity. Concurrently, providing nutritionally balanced meals and other vital foods in specific cafeterias of the workplace may even boost the adoption of nutritional choices that have the potential to improve overall well-being.

The use of SSDs has been demonstrated to be an effective means of inducing healthy food choices. Further research should examine the long-term (i.e., over 1 year) and sustained impact of SSD, investigating whether observed changes occur after their use, and whether they result in enduring psychological and physiological effects. The findings from this thesis reinforce the need for more companies and worksites to adhere to this strategy, with promising results ahead.

REFERENCES

Alosaimi, N., Sherar, L. B., Griffiths, P., & Pearson, N. (2023). Clustering of diet, physical activity and sedentary behaviour and related physical and mental health outcomes: A systematic review. *BMC Public Health*, *23*(1), 1572. https://doi.org/10.1186/s12889-023-16372-6

Arguello, D., Cloutier, G., Thorndike, A. N., Castaneda Sceppa, C., Griffith, J., & John, D. (2023). Impact of Sit-to-Stand and Treadmill Desks on Patterns of Daily Waking Physical Behaviors Among Overweight and Obese Seated Office Workers: Cluster Randomized Controlled Trial. *Journal of Medical Internet Research*, *25*, e43018. https://doi.org/10.2196/43018

Chau, J. Y., Sukala, W., Fedel, K., Do, A., Engelen, L., Kingham, M., Sainsbury, A., & Bauman, A. E. (2016). More standing and just as productive: Effects of a sit-stand desk intervention on call center workers' sitting, standing, and productivity at work in the Opt to Stand pilot study. *Preventive Medicine Reports*, *3*, 68–74. https://doi.org/10.1016/j.pmedr.2015.12.003

Daneshmandi, H., Choobineh, A., Ghaem, H., & Hejazi, N. (2021). Proper sit–stand work schedule to reduce the negative outcomes of sedentary behavior: A randomized clinical trial. *International Journal of Occupational Safety and Ergonomics*, *27*(4), 1039–1055. https://doi.org/10.1080/10803548.2019.1679972

Dutta, N., Koepp, G., Stovitz, S., Levine, J., & Pereira, M. (2014). Using Sit-Stand Workstations to Decrease Sedentary Time in Office Workers: A Randomized Crossover Trial. *International Journal of Environmental Research and Public Health*, *11*(7), 6653–6665. https://doi.org/10.3390/ijerph110706653

Jones, M. D., Clifford, B. K., Stamatakis, E., & Gibbs, M. T. (2024). Response to Comment on "Exercise Snacks and Other Forms of Intermittent Physical Activity for Improving Health in Adults and Older Adults: A Scoping Review of Epidemiological, Experimental and Qualitative Studies." *Sports Medicine*, *54*(8), 2205–2207. https://doi.org/10.1007/s40279-024-02081-6

Josaphat, K.-J., Labonté-Lemoyne, É., Sénécal, S., Léger, P.-M., & Mathieu, M.-E. (2020). Acute Impact of the Use of a Standing Desk on Appetite Sensations and Energy Intake. *Journal of Physical Activity and Health*, *17*(12), 1240–1246. https://doi.org/10.1123/jpah.2019-0444

Júdice, P. B., Hamilton, M. T., Sardinha, L. B., Zderic, T. W., & Silva, A. M. (2016). What is the metabolic and energy cost of sitting, standing and sit/stand transitions? *European Journal of Applied Physiology*, *116*(2), 263–273. https://doi.org/10.1007/s00421-015-3279-5

Júdice, P. B., Silva, H., Teno, S. C., Monteiro, P., Silva, M. N., Carraça, E. V., Santos, I., Pereira, S., Luz, F., Viegas, P. C., Oliveira, J., Santos, I. F., & Palmeira, A. L. (2023). Providing office workers with height-adjustable workstation to reduce and interrupt workplace sitting time: Protocol for the Stand Up for Healthy Aging (SUFHA) cluster randomized controlled trial. *Trials*, *24*(1), 381. https://doi.org/10.1186/s13063-023-07407-9

Leow, S., Beer, N. J., Dimmock, J. A., Jackson, B., Alderson, J. A., Clarke, M. W., & Guelfi, K. J. (2021). The effect of antecedent exercise on the acute stress response and subsequent food consumption: A preliminary investigation. *Physiology & Behavior*, *229*, 113256. https://doi.org/10.1016/j.physbeh.2020.113256

Ma, J., Ma, D., Li, Z., & Kim, H. (2021). Effects of a Workplace Sit–Stand Desk Intervention on Health and Productivity. *International Journal of Environmental Research and Public Health*, *18*(21), 11604. https://doi.org/10.3390/ijerph182111604

Metz, L., Guirado, T., Beaulieu, K., Pereira, B., Brun, C., Coutarel, F., Duclos, M., & Thivel, D. (2023). Cognitive work on a walking desk does not lead to compensatory appetitive responses in healthy young adults. *Physiology & Behavior*, *258*, 114008. https://doi.org/10.1016/j.physbeh.2022.114008

Michalchuk, V. F., Lee, S.-J., Waters, C. M., Hong, O. S., & Fukuoka, Y. (2022). Systematic Review of the Influence of Physical Work Environment on Office Workers' Physical Activity Behavior. *Workplace Health & Safety*, *70*(2), 97–119. https://doi.org/10.1177/21650799211039439

Michels, N., Man, T., Vinck, B., & Verbeyst, L. (2020). Dietary changes and its psychosocial moderators during the university examination period. *European Journal of Nutrition*, *59*(1), 273–286. https://doi.org/10.1007/s00394-019-01906-9

Nakagata, T., Yamada, Y., Hatamoto, Y., & Naito, H. (2019). Energy Expenditure of a Single Sit-to-Stand Movement with Slow Versus Normal Speed Using the Different Frequency Accumulation Method. *Medicina*, *55*(3), 77. https://doi.org/10.3390/medicina55030077

Nyhus Dhillon, C., & Ortenzi, F. (2023). Assessing the Impact of Workforce Nutrition Programmes on Nutrition, Health and Business Outcomes: A Review of the Global Evidence and Future Research Agenda. *International Journal of Environmental Research and Public Health*, *20*(9), 5733. https://doi.org/10.3390/ijerph20095733

Rocha, J., Paxman, J., Dalton, C., Winter, E., & Broom, D. R. (2016). Effects of a 12-week aerobic exercise intervention on eating behaviour, food cravings, and 7-day energy intake and energy expenditure in inactive men. *Applied Physiology, Nutrition, and Metabolism*, *41*(11), 1129–1136. https://doi.org/10.1139/apnm-2016-0189

Saeidifard, F., Medina-Inojosa, J. R., Supervia, M., Olson, T. P., Somers, V. K., Erwin, P. J., & Lopez-Jimenez, F. (2018). Differences of energy expenditure while sitting versus standing: A systematic review and meta-analysis. *European Journal of Preventive Cardiology*, *25*(5), 522–538. https://doi.org/10.1177/2047487317752186

Schuman-Olivier, Z., Trombka, M., Lovas, D. A., Brewer, J. A., Vago, D. R., Gawande, R., Dunne, J. P., Lazar, S. W., Loucks, E. B., & Fulwiler, C. (2020). Mindfulness and Behavior Change. *Harvard Review of Psychiatry*, *28*(6), 371–394. https://doi.org/10.1097/HRP.0000000000000277

Solomon, T. P. J., Tarry, E., Hudson, C. O., Fitt, A. I., & Laye, M. J. (2020). Immediate post-breakfast physical activity improves interstitial postprandial glycemia: A comparison of different activity-meal timings. *Pflügers Archiv - European Journal of Physiology*, *472*(2), 271–280. https://doi.org/10.1007/s00424-019-02300-4

Strain, T., Flaxman, S., Guthold, R., Semenova, E., Cowan, M., Riley, L. M., Bull, F. C., & Stevens, G. A. (2024). National, regional, and global trends in insufficient physical activity among adults from 2000 to 2022: A pooled analysis of 507 population-based surveys with 5·7 million participants. *The Lancet Global Health*, *12*(8), e1232–e1243. https://doi.org/10.1016/S2214-109X(24)00150-5

Tan, C. C., & Chow, C. M. (2014). Stress and emotional eating: The mediating role of eating dysregulation. *Personality and Individual Differences*, *66*, 1–4. https://doi.org/10.1016/j.paid.2014.02.033

Thackray, A. E., & Stensel, D. J. (2023). The impact of acute exercise on appetite control: Current insights and future perspectives. *Appetite*, *186*, 106557. https://doi.org/10.1016/j.appet.2023.106557

APPENDICES

Mediterranean Food Pattern Adherence Questionnaire:

Com que frequência consome:	*Frequência de consumo (número de porções regulares por semana)*					
Cereais não refinados (pão integral/de mistura, massa e arroz integral, etc.)	Nunca	1-6	7-12	13-18	19-31	>=32
(1 porção equivale a 1 fatia de pão/1 bola, ½ chávena de arroz ou massa)						
Batatas	Nunca	<1	1-2	3	4	>=5
(1 porção equivale a ½ chávena de batata cozida/puré, 1 chávena de batatas fritas, 1,5 batatas cruas)						
Fruta	Nunca	1-4	5-8	9-15	16-21	>=22
(1 porção equivale a 1 peça de fruta média, por exemplo, 1 maçã/laranja, 1 banana pequena, 1 fatia de melancia/melão, 10-12 cerejas/morangos/uvas)						
Hortícolas (crus ou cozinhados)	Nunca	1-6	7-12	13-20	21-32	>=33
(1 porção equivale a 1 chávena almoçadeira de hortícolas crus e ½ chávena cozinhados)						
Leguminosas (grão, feijão, ervilhas, etc.)	Nunca	<1	1-2	3-4	5-6	>=7
(1 porção equivale a 1 chávena)						
Peixe (e derivados do mar)	Nunca	<1	1-2	3-4	5-6	>=7
(1 porção equivale a 120g de peixe cozinhado)						
Carnes vermelhas e produtos de charcutaria	≤1	2-3	4-5	6-7	8-10	>=11
(1 porção equivale a 120g de carne cozinhada)						
Carnes brancas (de aves)	≤3	4	5-6	7-8	9-10	>=11
(1 porção equivale a 120g de carne cozinhada)						
Lacticínios gordos (queijo, iogurte, leite)	≤10	11-15	16-20	21-28	29-30	>=31
(1 porção equivale a 1 chávena de leite, 1 iogurte de 180g, 30g de queijo; se consome apenas leite meio-gordo ou magro, escolher a opção ≤10 por semana.)						
Uso de azeite na confeção (vezes/semana)	Nunca	Raramente	<1	1-3	3-5	Diariamente
Bebidas alcoólicas (ml/dia, 1 copo de vinho = 100ml)	<300	300	400	500	600	>=700 ou 0

Committee on Ethics:

UNIVERSIDADE LUSÓFONA
I Faculdade de Educação Física e Desporto [redacted]

Comissão de Ética da Faculdade de Educação Física e Desporto -ULHT

Parecer D0522

A Comissão de Ética da Faculdade de Educação Física e Desporto – ULHT, em reunião de 5 de Dezembro de 2022, analisou o projeto *The impact of introducing sit-stand desks in the workplace for healthy aging: a randomized controlled trial in sedentary adults*, com o acrónimo designado por *SUFHA (Stand Up For Healthy Aging)*, a realizar por quatro centros de investigação (Centro Investigação em Desporto, Educação Física, Exercício e Saúde -*CIDEFES* da Faculdade de Educação Física e Desporto; Centro de Investigação em Comunicação Aplicada, Cultura e Novas Tecnologias - *CICANT*- da Escola de Comunicação, Arquitetura, Artes e Tecnologias da Informação, *COW* - Centro de Investigação em Design e Arte - Center for Other Worlds, e *HEI-LAB* – Human Environment Interaction laboratory), cujo investigador principal é o **Pedro Júdice**, tendo decidido emitir parecer positivo sem recomendações.

O Diretor da Comissão de Ética da FEFD – ULHT

Faculdade de Educação Física e Desporto

(Prof. Doutor José Gregório Viegas Brás)